- Water (Variables)

  This worksheet in the main PCA water database consists of a list of the original fields: ParamID and UnitsID for all retained variables in the Water (SWGW) worksheet. The EDA_Variable and EDA_UnitsID fields located adjacent to the original fields show the assignments made for purposes of processing in EDAnalyzer and SYSTAT. This worksheet documents the variables (EDA_Variable) and units (EDA_UnitsID) assigned to the data for use in the PCA.

- Water (P Protocol)

  This worksheet in the main PCA water database contains a cross-tabulation of the various phosphorus data (in rectangular or tabular form) retained for PCA use and documents the protocol for assigning data to the three forms of phosphorus used in the PCA: soluble reactive phosphorus (P_Sol_Reac), total phosphorus (P_T), and total dissolved phosphorus (P_TD).

- USGS (N DB)

  This worksheet in the main PCA water database contains a copy of the USGS data for various nitrogen analyses. This worksheet was used to construct a cross-tabulation of these data, provided in the worksheet: USGS (N CT) discussed below.

- USGS (N CT)

  This worksheet in the main PCA water database contains a cross-tabulation for use in evaluating and assigning the USGS nitrogen data to the appropriate variables. The original ParamID: Ammonia Nitrogen refers to USGS method code P00625, Ammonia + Organic Nitrogen (mg/L as N). Since this is the same as total Kjeldahl nitrogen (TKN), data corresponding to P00625 were assigned the code: TKN in the EDA_Variable field.

The worksheets in the main PCA solids database were similar to those in the water database and are therefore only briefly summarized below:

- Solids (SD)

  This worksheet in the main PCA solids database contains the portion of the data (in linear data records or database form) to be retained for PCA use.

- Solids (Out)

  This worksheet in the main PCA solids database contains the portion of the data not retained for PCA use.

- Solids (Variables)

  This worksheet in the main PCA solids database contains a list that documents the variables and units assigned to the data used in the PCA.

- Solids (P Protocol)

This worksheet in the main PCA solids database contains a cross-tabulation of the various phosphorus data (in rectangular or tabular form) retained for PCA use and documents the protocol used to assign data to the form of phosphorus used in the PCA: total phosphorus (P_T).

The process followed in retaining (or not retaining) data for PCA use and applying the various protocols documented in the two main databases was developed based on Steps 1-5 and the experience gained during a previous, preliminary set of PCA runs. As this preliminary work was conducted on an incomplete database (recently collected data were not included) they are not discussed further or presented in this report.

In summary, for the water samples, a total of 82,111 individual data records were extracted from the master database or created during processing in the main PCA water database. Of these, 49,088 records were retained for use in the PCA and 33,023 records were not retained. The retained data contained results for 66 analytical parameters, which were each assigned one of 40 unique variable codes for use in the various investigative and sensitivity PCA runs described in this report.

Similarly, for the solids samples, a total of 18,546 individual data records were extracted from the master database or created during processing in the main PCA water database. Of these, 13,101 records were retained for use in the PCA and 5,445 records were not retained. The retained data contained results for 98 analytical parameters (note: this number is higher than in the case of the water database due to inclusion of both dry weight and wet weight data), which were each assigned one of 41 unique variable codes for use in the various investigative and sensitivity PCA runs described in this report.

Individual EXCEL sub-database files were created from the main databases for use in the actual PCA runs; i.e., for import into EDAnalyzer. These sub-database files were given names all beginning with "Subdatabase" and include a sequence number that indicates the date (month and day) of creation. The date indicator was used for documentation purposes, in order to allow tracking of the various PCA runs and result files to a particular sub-database. The sub-databases were exact copies (on the date indicated) of the data contained in the nine EDA fields located in the retained data worksheets of the two main database workbooks. Following is a listing of the sub-database files used in the PCA:

- Subdatabase_Water_0427.xls
- Subdatabase_Water_0428.xls
- Subdatabase_Solids_0429.xls
- Subdatabase_Solids_0430.xls
- Subdatabase_Solids_0501.xls
- Subdatabase_Solids_0502.xls

Step 7: Perform Distributional and Data Exploration Analyses

Data exploration or exploratory data analysis (EDA) is a key component of, and is integrated directly into, the PCA conducted during this investigation. In fact, the name of the CDM-developed EXCEL Add-In program: EDAnalyzer means "Exploratory Data Analyzer". EDAnalyzer is a tool specifically developed for analysis of multivariate datasets, allowing interactive EDA in order to: (1) examine the distributions of and select appropriate variables (analytes) for PCA, (2) determine appropriate variable transformations, and (3) identify possible outliers for further review and/or elimination. In addition, EDAnalyzer performs PCA (via a shell to the SYSTAT program) and loads, displays, and saves PCA results for further examination.

EDAnalyzer was not the only approach used for EDA in this investigation: other EDA methods were conducted outside of the EDAnalyzer program. The results of these other methods are discussed in appropriate locations in this report.

EDAnalyzer operates by first loading the appropriate sub-database file (listed at the end of Step 6). Selections are then made of the various groups (EDA_Group), variables (EDA_Variable), and samples (EDA_Sample) of interest to a particular analysis or run. An option under sample selection is used to set the criterion to be used to limit the retaining of samples to a desired level of completeness of the variables, e.g., samples with data for at least 20 of 26 variables. Another option is used to set the multiplier for handling nondetect data (note: for all PCA runs conducted during this investigation, the multiplier was set to 0.5, meaning that the result was set to one-half of the detection limit). The program then generates a cross-tabulation of the data (samples in rows by variables in columns) based on the selections and options. During generation of the cross-tabulation, the nondetect multiplier is applied and the results for replicates (e.g., field splits) are averaged. The program then generates descriptive statistics and a correlation matrix for the cross-tabulation.

The correlation matrix was used only as a means of identifying possible "holes" in the matrix for purposes of the PCA, and was not used as input to the actual PCA. Holes in the correlation matrix are due to variables with an insufficient number of results relative to other variables. These variables were identified during previous, preliminary PCA runs and used to remove variables; therefore, for the current PCA it was typically not necessary to examine the correlation matrix for holes that would prevent the PCA from running.

The descriptive statistics generated for each variable were as follows:

- Count
- Mean
- Median
- Minimum

- Maximum
- Standard Deviation
- Skewness
- Kurtosis

In conjunction with the descriptive statistics (listed above), probability plots (or pplots) are generated in order to examine the distributional shape of the data for each variable. An interactive tool is used to examine the effect of various transformations on the distributions. The possible transformations available in EDAnalyzer are: natural logarithm, base-10 logarithm, square, and square-root. This step is important in the PCA for two reasons: (1) it is desirable to have distributions that are near-normally shaped and (2) it is desirable to re-scale the data so as to minimize the affect on the PCA of variables with widely varying concentrations, distributions, and units of measure. In practice, for most of the PCA runs, data were base-10 log transformed for all variables (although there were exceptions) to obtain near-normal distributions for most of the paramets and to minimize the affect of highly variable concentrations and units of measure. This is a common practice for environmental data which are typically log-normally distributed. As an example, the probability plots for run surface samples (SW3) are provided in **Appendix E.**

The descriptive statistics and pplots were also used to identify anomalous data or outliers. Such outliers were always checked to verify that they were not the result of transcription errors in the project database or on laboratory reports. In cases where transcription errors were identified, these were corrected in the main database and a new sub-database generated for PCA (note: this iterative process is one reason for the multiple sub-databases listed at the end of Step 6: to allow documentation of these corrections). In cases where transcription errors could not be verified for the outliers, they were either retained in the PCA or were eliminated by removing an entire sample. Such eliminated samples (which were always few in number) were removed via an interactive tool on the generated cross-tabulation. The following samples were removed as outliers in selected and corresponding PCA runs:

- EOF-SPREAD073B:6/18/2006:SW:S:-:-

This is an edge-of-field runoff sample that exhibited anomalously high concentrations for several variables. Some of the values reported seem to be laboratory errors; however, the laboratory error could not be confirmed.

- LK-01:5/17/2006:SW:S:0:-
- LK-02:5/16/2006:SW:S:0:-

These are surface water samples collected from Lake Tenkiller that exhibited anomalously high sulfate values (7,055 and 7,032 mg/L, respectively). These values are obvious laboratory errors.

- MAN-BC-20D:3/31/2008:SW:S:-:(SPLP-4-1)
- MAN-BC-22F:4/1/2008:SW:S:-:(SPLP-4-1)
- MAN-BC-24D:4/3/2008:SW:S:-:(SPLP-4-1)
- MAN-BC-24F:4/3/2008:SW:S:-:(SPLP-4-1)

These are cow manure leachate samples that exhibit extremely high concentrations for several variables. All 4:1 leachate samples were excluded from the PCA in lieu of 20:1 leachates which are considered more realistic of runoff.

- FAC-16:12/14/2007:SW:S:-:(SPLP-4-1)
- FAC-16:12/14/2007:SW:S:-:(SPLP-20-1)
- FAC-17:12/19/2007:SW:S:-:(SPLP-20-1)

These are chicken waste leachate samples that exhibit extremely high concentrations for several variables.

- EOF-Q1:6/17/2006:SW:S:-:-
- EOF-Q2:6/17/2006:SW:S:-:-
- EOF-Q3:6/18/2006:SW:S:-:-
- EOF-Q4:6/18/2006:SW:S:-:-

These are edge-of-field samples that were not selected because the actual locations and collection process could not be documented.

In summary, the EDA (descriptive statistics and the pplots) were used to help identify a set of variables and samples to be retained for the PCA. This process is discussed in further detail in Step 8.

Step 8: Identify Parameters that Meet PCA Criteria

The identification of parameters (variables) that meet PCA criteria was an iterative process. Ultimately, this determination was made during EDA as discussed in Step 7. However, much of the actual identification and selection occurred and is documented in the main databases (Step 6) based on previous, preliminary PCA runs and other calculations. Overall, the criteria used to identify parameters for PCA are stated and discussed below:

- Include as many parameters as possible.

  This criterion is designed to allow more definitive and accurate distinction of sources of contamination, to better explain differences in waste compositions, and to better explain relationships of waste composition. This is an overall PCA and investigative objective.

- Exclude redundant parameters.

  Parameters that measure similar attributes or composition of the samples were excluded from the PCA in most cases to avoid placing to much weight on similar constitutents. For example, conductivity was excluded in the water PCA runs because it measures the same attribute as total dissolved solids (TDS). In addition, dissolved metals were typically excluded in the water PCA runs in lieu of total metals since dissolved metals measure the same attribute and are typically a substantial portion of total metals. Metals (e.g., copper) tend to form complexes with the large amount of organic matter in the poultry waste (see Moore et al. 1998). Hence total metals, which include both complexed and colloidal forms, better represent the metal transport during field runoff and subsequent transport in streams. Use of total metals also avoids any problems associated with the small amount of samples where dissolved concentrations were reported higher than total concentrations (see section 3.10 for discussion). Sensitivity runs (see Step 14) were performed with both dissolved and total metals (either total or dissolved).

  Various forms of phosphorus were also excluded due to potential redundancy (and other reasons) in both the water and solids PCA runs. In the water runs, only three forms of phosphorus were retained: total dissolved phosphorus (filtered; P_TD), soluble reactive phosphorus (filtered; P_Sol_Reac), and total phosphorus (not filtered; P_T). These three forms of phosphorus were retained because they are the most important forms used in modeling and other evaluations, and because, though somewhat redundant, they may aid in distinguishing sources. In addition, selected phosphorus analytical methods were eliminated based on protocols established and documented in the main water and solids databases. In all cases, phosphorus by method 6010 was eliminated because it was shown to have interferences and resulted in inaccurate data (see Section 3.8). Even though phosphorus by method 6020 provided reliable results (see Section 3.8), it was redundant with total phosphorus (not filtered) and dissolved total phosphorus (filtered). In addition, phosphorus results by method 4500 (Standard Methods) were typically used in lieu of phosphorus results by method 365.2 because the detection limits were lower. See Section 3.8 for a more complete discussion and comparison of phosphorus methods. In addition, sensitivity runs were performed with only one of the phosphorus parameters (vs. three). This and other sensitivity run results are discussed further in Step 14.

- Exclude parameter results by unreliable methods.

  As previously discussed, phosphorus by method 6010 was eliminated because results were not accurate.

- Exclude parameters that were not routinely analyzed.

- Variables with low relative numbers of observations (counts) were not retained for the PCA. The basis for this criterion was to minimize the impact of missing data on

PCA, which affects the ability of the PCA to generate reliable PC scores. Retaining these parameters would create "holes" in the correlation matrix and statistical evaluations could not be performed. **Tables 6.11-4a** (water) and **6.11-4b** (solids) provides a list of parameters not routinely analyzed that were excluded from the PCA.

- Exclude parameters with a substantial amount of nondetects.

  Variables with relatively high percentages of nondetects (as indicated on the pplots or by calculations) were not retained also for the PCA. The basis for this criterion was two-fold: either such variables were considered of insufficient variance (i.e., constants) or they were deemed to have too few observations above analytical detection limits to be reliably used for the PCA. These variables were identified iteratively during previous, preliminary PCA runs, and hence were removed at the main database stage during the current analyses. **Tables 6.11-5** (water) and **6.11-6** (solids) provide the frequency of detection for each of the measured parameters that were retained and that were excluded. As shown for the water samples, the frequency of detection of all retained parameters was typically larger than 55 to 60 percent except for total arsenic (46% detections in water). Arsenic was retained for the water PCA runs because it is an important parameter in distinguishing poultry waste from other wastes (it is added to poultry feed). A sensitivity analysis was performed with and without arsenic (see Step 14). No significant differences were observed in the results. In addition, some of the dissolved metals (aluminum, iron and arsenic) have lower frequency of detections. For major runs, only total metal concentrations were used. In addition, sensitivity runs were performed using dissolved metals instead of total metals (see Step 14). For solids, the frequency of detection for retained parameters was typically above 70 percent expect for sodium, beryllium and staphylococcus.

- Select parameters with good variability and good distribution.

  Variables with low relative variability as indicated by their limited range (maximum - minimum) and/or small standard deviation were not retained for purposes of the PCA. The basis for this criterion was to minimize the impact on the PCA of variables with low or insufficient variance, since such variables were either not useful for the PCA or are considered constants (not variables). During Step 7, descriptive statistics (minimum, maximum, etc) and probability plots were evaluated. Probability plots (of transformed data as applicable) were examined visually to ensure that the measured concentrations had a good distribution (near linear plot with good variation of concentrations from low to high). Example probability plots are provided in **Appendix E**.

- Exclude parameters for which concentrations in the waste source are similar to background concentrations and as a result may not provide good variation in the environmental samples.

  For example, nickel in both poultry waste and background soils have similar concentrations. Originally (in previous, preliminary PCA runs), nickel was excluded from the PCA. However, based on the frequency of detection (60%), it was decided to retain nickel in subsequent analyses. Sensitivity analyses was performed during previous PCA runs with and without nickel to determine if any large differences were observed (see Step 14). No significant differences were observed in the results. All PCA runs for this report included nickel.

Based on the above criteria and evaluations, a maximum of 26 water parameters, and a maximum of 32 solids parameters, were selected for the various PCA runs. For some of the sensitivity and investigative runs (see Section Step 14), these numbers were lower (e.g., 24 parameters were selected in the water sensitivity runs using only one of the three phosphorus parameters). For the two main water PCA runs presented in detail in this report (SW3 and SW17), the parameters retained and included in the PCA were as follows:

Total Aluminum	Alkalinity
Total Arsenic	Total Barium
Total Calcium	Chloride
Total Coliforms	Total Copper
E. coli	Enterococcus
Total Iron	Fecal Coliforms
Total Potassium	Total Magnesium
Total Manganese	Total Sodium
Total Nickel	Nitrite + Nitrate
Soluble Reactive Phosphorus	Total Dissolved Phosphorus
Total Phosphorus	Sulfate
Total Dissolved Solids	Total Kjeldahl Nitrogen
Total Organic Carbon	Total Zinc

For one of the two main solids PCA runs presented in detail in this report (SD1), the parameters retained and included in the PCA were as follows:

Total Aluminum	Total Arsenic
Total Barium	Total Beryllium
Total Calcium	Total Cobalt
Total Coliforms	Total Chromium
Total Copper	E. coli
Enterococcus	Total Iron
Fecal Coliforms	Total Mercury
Total Potassium	Total Magnesium
Total Manganese	Total Sodium
Water Soluble Ammonium	Total Nickel
Total Nitrogen	Organic Matter
Phosphorus (Mehlich 3)	Total Phosphorus
Water Soluble Phosphorus	Total Lead

pH (1:1)	Soluble Salts
Water Soluble Sulfate	Staphylococcus
Total Vanadium	Total Zinc

For the second of the two main solids PCA runs presented in detail in this report (SD6), which included core samples collected from Lake Tenkiller, the parameters retained and included in the PCA were as follows:

Total Aluminum	Total Arsenic
Total Barium	Total Beryllium
Total Calcium	Total Cobalt
Total Chromium	Total Copper
Total Iron	Total Mercury
Total Potassium	Total Magnesium
Total Manganese	Total Sodium
Total Nickel	Total Nitrogen
Organic Matter	Total Phosphorus
Total Lead	pH (1:1)
Soluble Salts	Total Vanadium
Total Zinc	

The above list for the included core samples differs from the previous list (without the core samples) because the core samples were not analyzed for as many parameters. For example, the core samples were not analyzed for bacteria. Hence the PCA runs that included the core samples were reduced to a smaller number of variables.

Step 9: Normalize and Standardize Data and Perform PCA

As discussed in the previous Steps 7 and 8, typically all data used in the PCA were first normalized by using a log (base 10) transformation. In addition, standardization in the form of an autoscale (or z) transformation is conducted automatically by SYSTAT during a PCA run by analyzing a correlation matrix. The autoscale transformation, which ensures homogeneity of variance in the PCA, is defined as follows:

$$z_{ij} = \frac{x_{ij} - \bar{x}_i}{s_i}$$

where z_{ij} is the datum (typically though not always base-10 log transformed) for variable i and sample j, and $\bar{x}_i$ and s_i are the mean and standard deviation, respectively, of the data (again, typically base-10 log transformed) for variable i and all samples.

As previously discussed, the EXCEL add-in program EDAnalyzer is used to facilitate the PCA. The EDAnalyzer program performs three primary functions: (1) interactive selection of groups, variables, and samples via distributional and data exploration analyses, including graphical displays; (2) generation of SYSTAT datasets and command files, and the running of the SYSTAT program via a shell application; and (3) managing and loading of SYSTAT result files for interactive graphical displays, along with options for saving selections and results files. These functions are described in further detail below. Note that EDAnalyzer is a utility program: all of its functions can be performed by hand prior to and following PCA analysis in SYSTAT; however, hand-performance of these functions is tedious and subject to mistakes, and therefore EDAnalyzer was used to ensure that a standard process was used.

Sub-databases (e.g., Subdatabase_Water_0428.xls) are loaded into EDAnalyzer. Using the fields: EDA_Group, EDA_Sample, and EDA_Variable, the user selects a set of records pertinent to the desired PCA. The selections are stored on the worksheet: Selections, which can be saved to a file in order to document the selections. Distributional and EDA is conducted via generation of a cross-tabulation, which is the rectangular (samples in rows and variables in columns) dataset that SYSTAT uses for actual PCA analysis (provided on the worksheet: Crosstab). The cross-tabulation is interactively examined to identify samples with a sufficient number of variables for PCA analysis. EDAnalyzer has an option for selecting a minimum number of variables, e.g., at least 20 of 26 variables. EDAnalyzer also has an option for creating (or averaging) the cross-tabulation by sample or by location; e.g., in the case of by location, the data for a particular variable with multiple samples assigned to that location would be averaged during creation of the cross-tabulation. For the current PCA runs in this report, no averaging is performed except when actual field splits (duplicates) were sampled, and no averaging is performed for samples collected at the same locations but at different times. In addition, EDAnalyzer has an option for selecting a multiplier for use on nondetect data: for all current PCA runs this multiplier was set to 0.5, meaning that values below analytical detection limits were set to one-half the detection limit.

As previously discussed in Step 7, distributional and data exploration analyses conducted in EDAnalyzer includes generation of a Pearson r correlation matrix (provided on the worksheet: Matrix). The correlation matrix is examined to ensure that (1) there will be no holes in the matrix, i.e., cases where a correlation cannot be calculated due to insufficient data and (2) there will be no cases with a correlation of 1, since that would indicate a condition where a variable was actually a constant in the PCA. Examination of the correlation matrix within EDAnalyzer is only a convenience in that SYSTAT can not perform PCA if the above conditions are not met – otherwise the correlation matrix generated in EDAnalyzer is not used directly by SYSTAT. As previously discussed, distributional and data exploration analyses conducted in EDAnalyzer also includes generation of various descriptive statistics and graphical displays (provided on the worksheet: Statistics). These are interactively examined and explored. The descriptive statistics are provided for each variable and include: Count, Minimum, Maximum, Mean, Median, Variance, and Standard Deviation. In addition, a normal probability plot is provided in order to allow examination of the distributional shape of the data and to assess the number of nondetects. EDAnalyzer has an interactive tool that allows the user to select various possible data transformation functions, including logarithmic, square, and square root, to view the transformed data on the probability plot, and then to save a selected transformation for subsequent inclusion as a command in the SYSTAT command file created by EDAnalyzer. The protocol used was to select the transformation that most closely "normalizes" the variables - typically this was the logarithmic (base 10) transformation. Finally, the probability plots and accompanying descriptive statistics are examined to ensure that the variable has sufficient variance (variability) to be considered a useful variable in the PCA. Variables with insufficient variance, or a large percentage of nondetects, are not useful variables and may cause the SYSTAT PCA to not execute.

Once interactive selection and data exploration are completed, EDAnalyzer creates the dataset (essentially a copy of the Crosstab worksheet) and the command file for the SYSTAT PCA. EDAnalyzer then shells out to SYSTAT via execution of the command file. The command file contains instructions to SYSTAT for creating and managing input and output files and for transforming variables, along with the detailed instructions for the PCA. The SYSTAT output files are stored within a fixed-location folder and they are always given the same names. The user ensures that the PCA run was successfully completed (all commands were executed) - if not, SYSTAT provides an error message. Following successful execution, the output files in the fixed-location folder (from a previous PCA run, if any) are overwritten.

Following completion of a successful PCA run in SYSTAT, control goes back to EDAnalyzer and the user then loads the SYSTAT results directly into EDAnalyzer into various worksheets: Standard - which contains the standardized data generated in SYSTAT and actually used in the PCA, and Results - which contains loadings, coefficients, percent variance explained, and PC scores for the first five principal components and for five different rotations. The PC scores are generated within EDAnalyzer using the coefficients and standardized data. Additionally, a re-scaled PC score is calculated for each sample or location. The Result worksheet also contains the EDA_Groups selected for the analysis.

Although EDAnalyzer only extracts results for the first (or top) five principal components, SYSTAT actually generates results for all possible principal components, one for each variable. EDAnalyzer only shows the results for the first five principal components because it is rare that information in components beyond the first 2-3 is useful in environmental studies.

After the Results worksheet is populated, EDAnalyzer uses this information to generate various PCA graphical displays (provided on the worksheet: Display). The graphical displays include: horizontal bar charts showing both the loadings and coefficients of the parameter for the first two PCs, a vertical bar graph which shows the percent variance explained by each of the five principal components, a PC by PC scatter plot showing the loadings with variable labels, a PC by PC scatter plot showing PC scores with sample/location labels, and a map (X versus Y coordinate) showing the sample/location points size-scaled according to the value of the PC score selected. EDAnalyzer provides an interactive tool that allows for selecting various principal components and rotations for graphical display.

The numerical PCA results on the Results worksheet can be and typically are saved to separate files in order to document the PCA and to save the results for subsequent analysis, graphical display, and mapping purposes. The graphical displays of the results generated within EDAnalyzer are not typically saved; however, EDAnalyzer can import saved results files in order to display them graphically at a later time. For all current PCA runs presented in this report, both the cross-tabulated dataset and the PCA results were saved to individual files. These files were given names corresponding to the date the PCA was conducted, e.g., Crosstab_Water_0427_SW_3.xls and Results_Water_0427_SW_3.xls are the saved cross-tabulation and results files for water PCA run SW 3 conducted on April 27, 2008. The sub-database loaded into EDAnalyzer, used in making a PCA run, and pertaining to the cross-tabulation and result files, is the file with the same or most recent previous "date" (e.g., for the example, this was the sub-database file named Subdatabase_Water_0427.xls).

The cross-tabulation and result files generated by EDAnalyzer and saved (as described above) were subsequently used to generate various additional files for data analysis and graphical display, depending on the current needs and level of analysis (e.g., sensitivity or investigative analysis). Generally, these additional files included a file with prefix "R_PC_Plot" that contains the PC 1 through PC 5 scores for all five rotations, along with a series of PC by PC scatter plots pertaining to all five rotations. These and other files were also generated in order to provide graphical displays and tabulations presented in this report.

Step 10: Identify Major Principal Components

The total variability (or variance) in a multivariate dataset is a function of the number of parameters and their individual variances. If the parameters exhibit no inter-relationships or mutual correlations then the proportion or percentage of the total variance explained by or accounted for by each variable (parameter) would be the same. For example, the percentage of the total variance accounted for by each variable in a dataset with $i = 26$ parameters, given no mutual correlations, would be $(1/i) \times 100 = (1/26) \times 100 = 3.85\%$. However, this is not true for a multivariate dataset where the parameters exhibit at least some degree of mutual correlation. Principal components analysis (PCA) is a commonly used multivariate statistical method for identifying these mutual correlations, if present, and re-apportioning the individual variances accordingly.

PCA operates by transforming a dataset with a large number of parameters, ostensibly with inherent mutual correlations, to a new set of uncorrelated reference parameters called principal components or PCs. The number of PCs is the same as the number of original parameters. However, the apportionment of the total variance among the PCs will depend not only on the number of PCs but on the mutual correlations exhibited by the original parameters that comprise the PCs. Given mutual correlations, the objectives of PCA are to: (1) identify those PCs that explain or account for relatively high percentages of the total variance in a dataset, and (2) examine these PCs in order to interpret meaningful relationships among the samples in the dataset. These objectives can only be met by PCA in those cases where the parameters exhibit mutual correlations—and hence the dimensionality of the parameters in a multivariate dataset can be reduced to a smaller number of significant PCs—and where these PCs exhibit relationships among the samples from which meaningful interpretations are possible. The term "significant" in this context means that a relatively high percentage of the total variance is accounted for (explained) by a small number of PCs.

Experience has shown that the objectives of PCA can be met in a dataset or environmental system dominated by a relatively few number of source impacts that exhibit mutual correlations among their parameters. In such cases a correspondingly high percentage of the total variance is explained by only a few PCs, typically 2-3 PCs. This is the reason why EDAnalyzer only extracts (for examination) the top or most significant five PCs: if the top five PCs do not account for a high percentage of the total variance in the system then there is little hope of interpreting meaningful relationships among the samples. In PCA, the PCs are sorted according to the percentage of total variance explained, i.e., from those PCs that account for the highest percentage to those that account for the lowest percentage. One then examines these percentages in order to identify the significant PCs, if any.

Many different PCA runs were conducted during this investigation, some of which have been classified as "sensitivity" analyses and some of which have been classified as "investigative" analyses. Those classified as sensitivity analyses were designed to evaluate the sensitivity on the PCA of using certain different parameter sets or sample groups. The sensitivity analyses and their results are discussed in more detail in Step 14. The investigative analyses were designed for more direct analysis and interpretation relative to identification of source signatures in the watershed. From the investigative PCA runs, four have been selected (two for water samples labeled SW 3 and SW 17, and two for solids samples labeled SD 1 and SD 6) as the most important to the investigation or project objectives. Hence the results of these four PCA runs are presented in detail in this report. Aside from their importance, these four runs are also representative of the method used to examine the significance of the PCs, as discussed above, and therefore will be used as such in this section.

One method of displaying the significance of the PCs graphically is a point plot of the percent variance explained versus each PC, where the number of PCs is equal to the total number of original variables—and hence one can show how the variances differ from a corresponding alternate case of no mutual correlations. Such a plot is known as a scree plot, the term "scree" meaning "rubble at the bottom of a cliff" and referring to the random noise in the dataset as the number of PCs increases. In this context, "random noise" refers to the variance attributable to the original variables (parameters) and unrelated to the significant PCs. **Figure 6.11-1** shows a scree plot for PCA run SW 3, which contained 26 variables and hence corresponds to 26 PCs, PC 1 through PC 26 on the plot. As shown, the top five PCs (PC 1 through PC 5; indicated with blue symbols) each account for more than $(1/i) \times 100 = (1/26) \times 100 = 3.85\%$ of the total variance in the dataset, the amount attributable to random noise or to each original variable, and hence are considered significant. The amount of variance actually explained by the top five PCs for SW 3 is 74.1%, a significant proportion of the total variance and a significant reduction in dimensionality: from 26 variables explaining 100% of the variance to 5 PCs explaining 74.1%. The remaining variance, $(100 - 74.1) \times 100 = 25.9\%$, is considered to be random noise and is unrelated to the first five PCs. An alternate way of displaying this same information is a scree plot in the form of a bar graph, as shown in **Figure 6.11-2** for SW 3. On the bar graph, the percentage of the total variance explained by the top five PCs are each indicated, i.e., 38.0% (PC 1), 18.2% (PC 2), 7.6% (PC 3), 5.3% (PC 4), and 4.9% (PC5). These variances indicate that PC 1 and PC 2 are by far the most important of the five together explaining 56.2% of the total variance, relative to PCs 3, 4, and 5 (17.8%). Similar plots for the other PCA runs are provided in **Figures 6.11-3** through **6.11-8**. These all clearly show that the top five PCs are significant (above random noise), and that the top two PCs are the most significant. These results were used to establish the top two PCs (PC1 and PC2) as representing the dominant signals or signatures related to impacts in the watershed. The dominant PC1 and PC2 signatures also proved to be interpretable as to source identification because they are so dominant - see steps 12 and 13. On the other hand, PCs 3, 4, and 5 generally were less readily interpretable (because they are so much closer to random noise or background variation).

For the two water PCA runs (SW 3 and SW 17), there is no particular advantage of one scree plot version over the other: they both show the same information. However, for the two solids PCA runs (SD 1 and SD 6), the bar graph version has the advantage of also showing an alternate PCA rotation (called the varimax rotation) that proved useful for additional interpretation of the sample PC scores, as discussed further in this report. The objective of varimax rotation is to use the significant PCs (in this case PC 1 through PC 5, i.e., ignoring the insignificant PCs 6 through 26) and rotate or adjust their PC axes to maximize the variance of the variable loadings (closer to +1 or -1). This rotation proved to assist the interpretation in terms of the original variables and to allow more definitive distinctions of PC scores, in the cases of the solids PCAs. As shown on the corresponding figures, the varimax rotation apportions the percentage of total variance differently; however, the total variance explained by the top five PCs is the same: in the case of SD 1, 81.4%, and in the case of SD 6, 81.7%. Again, as in all PCA runs, the PCA in all cases successfully reduced the dimensionality of the datasets from a large number of original variables to a relatively few significant PCs, hence allowing for meaningful interpretations of source impacts in the watershed.

A summary of the variance explained by PC1 and PC2 for each of the four major PCA runs are shown below:

Run	Groups	Rotation	Variance Explained by PC1 (%)	Variance Explained by PC2 (%)	Variance Explained by PC1 and PC2 (%)
SW 3	Surface Waters	No Rotation	38.0	18.2	56.2
SW 17	Surface Waters and Groundwaters	No Rotation	34.2	15.9	50.1
SD 1	Solids (wastes, soils, sediments)	Varimax	38.3	16.7	55.0
SD 6	Solids and Core Samples	No Rotation	38.5	28.5	67.0

Each calculated PC (significant or otherwise) has associated with it a set of coefficients that relate the value of the PC to the values of the original variables. Hence these coefficients can be multiplied by the values of the original variables, and then summed, to calculate a PC score for each sample in the dataset. The method of calculating PC scores, and how these scores are used in evaluating the samples, is discussed in further detail in Step 11. The variance of the values (PC scores) of a particular PC for all samples in a dataset determines what is equal to a quantity called an eigenvalue, which is equal to the variance of the PC and therefore used to calculate the percent variance explained by the PC. For example, for PCA run SW 3, which contains 26 variables, the eigenvalue for PC 1 is 9.89, and therefore the percentage of the total variance explained by PC 1 is $(9.89/26) \times 100 = 38.0\%$, as is shown in **Figure 6.11-9.** This illustrates how these scree plots are generated.

The correlation between the values of the PCs for all samples and the corresponding values of the original variables is called a loading. A loading is a re-scaled coefficient such that they become correlation coefficients. Hence it is useful and meaningful to examine the loadings (or the coefficients) in order to determine the importance of the original variables for a particular PC. This is a key step in interpreting the PCs with regard to source signatures, as those variables with relatively high loadings (significant correlations) may be related in terms of geochemical mechanisms and transport pathways to similar high concentrations (or correlations) in the waste source. The actual interpretations of the PCs are presented and discussed in Step 12 of this report. The loadings and coefficients for four critical PCA runs (SW 3, SW 17, SD 1 and SD 6) are provided in **Figures 6.11-10** through **6.11-17**. **Figure 6.11-10** provides bar graphs of the loadings for PC 1 and PC 2 for PCA run SW 3. As shown, PC 1 exhibits relatively high positive loadings (greater than 0.6) for a large number of variables, including: arsenic, total coliforms, copper, e. coli, enterococcus, iron, fecal coliforms, potassium, nickel, total and total dissolved phosphorus, total organic carbon, and zinc. These are interpreted as the most important variables comprising

PC 1, and therefore if these or a subset of these variables can be shown to be related to a particular waste source, then samples with high PC 1 scores can be related to, or have signatures consistent with, that source. Similarly, PC 2 exhibits relatively high loadings for a different set of variables: chloride, sodium, and sulfate, which may indicate a relationship to another source. The threshold loading (0.6) in this example is arbitrary and has been selected solely for illustrative purposes: such thresholds are commonly adjusted based on additional information available to the investigator. **Figure 6.11-11** provides the bar charts for Run SW 3 for both PC1 and PC2 with the coefficients shown instead of the loadings. **Figures 6.11-12** and **6.11-13** provide the loadings and coefficients for PC1 and PC2 for SW17. **Figures 6.11-14a** and **6.11-15a** provide the loadings and coefficients for SD1. **Figures 6.11-14b** and **6.11-15b** provide the loadings and coefficients for SD1 using the varimax rotation. **Figures 6.11-16** and **6.11-17** provide the loadings and coefficients for PC1 and PC2 for SD6.

Step 11: Calculate Principal Component Scores

Principal component (PC) scores are calculated for each identified significant PC for each individual sample. Identification of significant PCs was discussed in Step 10. To calculate a PC score for each individual sample, the PC coefficient is multiplied by the standardized parameter concentration. This is performed for all parameters (variables) in a particular PCA run. The product values for all 25 parameters are summed to yield one PC score for each sample for each PC. Hence, a particular sample will have both a PC 1 score and a PC 2 score. If one of the variables selected in a particular PCA run is missing a value (due to it not being measured), the product (coefficient times the standardized concentration) for that parameter is essentially not used in the summation: this is the same as multiplying the coefficient by the standardized mean concentration which is zero. Sensitivity runs were performed using datasets with no missing value (Step 14)

Once the PC scores have been calculated for each significant PC, they are examined graphically via PC-by-PC scatter plots. Since EDAnalyzer extracts (for examination) the top five PCs, the number of scatter plots produced for possible examination will be: (5)(4)/2 = 10, i.e., PC 1 vs. PC 2, PC 1 vs. PC 3, PC 1 vs. PC 4, PC 1 vs. PC 5, PC 2 vs. PC 3, PC 2 vs. PC 4, PC 2 vs. PC 5, PC 3 vs. PC 4, PC 3 vs. PC 5, and PC 4 vs. PC 5. Furthermore, since the PCA is conducted using five different possible rotation variations: no rotation, varimax, equimax, quartimax, and oblimin, a total of: (10)(5) = 50 PC scatter plots were actually produced.

PC1 vs PC2 plots are provided for the following PCA runs:

- SW3 (Surface Water)
  - Figure 6.11-18a
  - Figure 6.11-18b (expanded view)
  - Figure 6.11-18c (shows two major groups - WWTP impacted waters and poultry waste impacted waters)
  - Figure 6.11-18d and e (sample types identified)

- SW17 (Surface Water and Groundwater)
  - Figure 6.11-19a
  - Figure 6.11-19b (expanded view)
  - Figure 6.11-19c and d (sample types identified)

- SD1 (Solid Samples)
  - Figure 6.11-20a
  - Figure 6.11-20b (expanded view)
  - Figure 6.11-20 c and d (sample types identified)
  - Figure 6.11-20e (PC2 vs PC3)
  - Figure 6.11-20f (PC1 vs PC2, no rotation)

- SD6 (Solid Samples including Lake Tenkiller core samples)
  - Figure 6.11-21a
  - Figure 6.11-21b (expanded view)
  - Figure 6.11-21c and d (sample types identified)

Examination of the PC scatter plots is a key step with regard to interpreting source signatures in the watershed: the analyst seeks to identify patterns, groupings, and relationships in the PC scores that distinguish the samples based on the various waste source impacts. This is discussed in further detail in Steps 12. The PC scores were also mapped in order to examine spatial and temporal relationships of the samples to the various waste sources. The PC scores typically range from negative to positive values. In this investigation, mapping was facilitated by re-scaling the PC scores such that the lowest score for a particular PC was assigned a value of one. This is also discussed in further detail in Steps 12.

Principal Component Scores are provided in **Appendix F** for all four major PCA runs conducted during this investigation and discussed in this report. There were a total of 22 water PCA runs (SW 1 through SW 22) and eight solids PCA runs (SD 1 through SD 6). **Tables 6.11-7a (Water) and 6.11-7b (Solids)** provide a summary of the PCA Runs.

Step 12: Evaluate Whether Major Components are Associated with Specific Sources

This step consists of two evaluations: 1) comparison of the principal component parameters to the composition of known waste sources and 2) a spatial and temporary analysis of individual principal component scores (for all major principal components).

Comparison to Known Waste Sources

In section 6.4.2, the chemical composition of cattle manure, poultry waste and waste water treatment plant discharges were provided (taken from literature values). **Tables 6.11-8, 6.11-9** and **6.11-10** provides the compositions of the PCA parameters for the following materials collected from the IRW:

- For Solid Samples (**Table 6.11-8**): 32 parameters
  - Average composition of 16 poultry waste samples
  - Average composition of 5 fresh cattle manure samples and 5 dry cattle manure samples
- For Synthetic Precipitation Leachate (SPLP) Samples (**Table 6.11-9):** 25 parameters
  - Average composition of two poultry waste leachates
  - Average composition of five fresh and five dry cattle manure leachate
  - Note, because the SPLP procedures require filtering, no total P was reported and all metals are dissolved concentrations (25 parameters versus 26).
- For Liquid Samples (**Table 6.11-10**): 26 parameters
  - Average composition of runoff from fields with poultry waste application (60 samples) - note, fields also had some cattle manure
  - Average composition of runoff from fields with potentially only cattle manure (two samples)
  - Average composition of two springs documented with cattle manure
  - Average composition of WWTP discharge from samples collected at Rogers discharge, Siloam Springs discharge and Springdale discharge (note - all samples were collected during high flow rates because of infiltration to lines after rain)
  - Average composition of surface water samples (25 samples) impacted by and collected downgradient of WWTP discharges

As shown in **Table 6.11-8**, the parameters highlighted in yellow have a different composition when compared to poultry waste. Parameters where poultry waste and cattle manure have distinctly different concentrations (by a factor of at least 3 times) are copper, phosphorus, potassium, zinc, manganese, arsenic, sulfate, sodium, calcium, soluble salts, nickel, aluminum, chromium, and some bacteria. **Figure 6.11-14b** provides the PC1 parameters and loadings sorted in order of importance for the solid samples (run SD1) including poultry waste, cattle manure, soil (0-2 inch), river sediments and Lake Tenkiller sediments (grab samples only). The parameters with the largest loadings and most importance in the PC (shown by the length of the vertical bars) are at the top of the figure while the loadings with the lowest coefficients and least importance are at the lower part of the figure. As shown, 24 of the 32 parameters have positive coefficients. Sixteen (16) of the parameters have significant loadings above 0.5. Parameters with the largest loadings in PC1 in order of importance follow: potassium, total P, sodium, magnesium, water soluble sulfate, total zinc, soluble salts, Mehlich 3 P, copper, calcium, organic matter, water soluble ammonia, water soluble P, total nitrogen, enterococcus and e. coli. As shown in **Table 6.11-8**, many of these parameters have very large concentrations in poultry waste and relative lower concentrations in cattle manure including potassium, phosphorus, sodium and sulfate.

Most important, the PC1 score vs PC2 score figure (**Figure 6.11-20a** and **c)** shows that the cattle manure plots on the figure in a distinctly different group than the poultry waste. These two groups are most clearly separated using the varimax rotation. However, the separate groups are also observed on the PC1 vs PC2 figure using no rotation (**Figure 6.11-20f**). These figures show that cattle manure and poultry waste have different and distinct chemical/bacterial signatures.

Table 6.11-9 compares the synthetic precipitation leachates from poultry waste and cattle manure. The parameter concentrations highlighted in yellow have distinctly higher concentrations in poultry waste leachate than cattle manure leachate by a factor of at least 3 times. These parameters include: copper, iron, TOC, nickel, potassium, zinc, arsenic, total dissolved P, soluble reactive P, TKN, total dissolved solids, sulfate, chloride, sodium and alkalinity. **Figure 6.11-10** provides the PC1 parameters and loadings sorted in order of importance for surface water samples. As shown, 22 of the 26 parameters have positive loadings. Nineteen (19) of the 26 parameters have loadings above 0.5. Parameters with the largest loadings in order of importance include: copper, e. coli, iron, TOC, total P, aluminum, nickel, fecal coliform, enterococcus, total coliform, potassium, zinc, manganese, arenic, total dissolved P and soluble reactive P. As shown, poultry leachate has very high concentrations of all of these parameters. A PAC run was performed with both poultry waste SPLP leachate and cattle manure SPLP leachate (SW18 - see **Appendix F**). This run shows that the poultry waste SPLP and the cattle manure SPLP samples are in distinct groups. No runs were performed with the SPLP poultry waste samples and surface water samples because the very high PC scores for the SPLP sample would dominate the analysis.

Table 6.11-10 provides the concentration information for liquid (water) related wastes including edge of field, WWTP discharges and surface waters impacted by WWTP discharges. As shown by concentrations highlighted in yellow, the chemical composition of runoff from poultry waste applied fields is different than runoff from fields with only cattle manure. All parameters with measured concentrations are different by a factor of 3 or more. **Table 6.11-10** also provides the chemical composition of WWTP effluent samples and for samples collected in streams (25 samples) directly downgradient of WWTP discharges. As shown, the chemical and bacterial composition of runoff from poultry waste applied fields is distinctly different when compared to the WWTP effluent or stream samples. Different (much higher) chemical and bacteria concentrations include: cooper, e. coli, iron, TOC, total P, aluminum, nickel, fecal coliform, enterococcus, total coliform, potsssium, zinc, manganese, arsenic, total dissolved P, soluble reactive P, TKN, and barium. These parameters have very high concentrations in runoff from fields with poultry waste and leachate from poultry waste. **Table 6.11-10** also show that springs (two samples) impacted with cattle manure have a different composition and lower concentrations than runoff from fields with poultry waste or poultry waste leachate for most parameters including copper, e. coli, iron, TOC, aluminum, nickel, fecal coliform, enterococcus, total coliform, zinc, manganese, arsenic, TKN and nitrite + nitrate.

Figure 6.11-10 shows the loadings for the 26 parameters for both PC1 and PC2 for surface water samples (SW3). As shown for PC1, 22 of the 26 parameters have positive loadings and 19 of the parameters have loadings greater than 0.5. All of these parameters have very large concentrations in runoff from fields with poultry waste and leachate from poultry waste. **Figure 6.11-10** also shows the loadings for the 26 parameters for PC2. As shown, 14 parameters have a positive loadings and 7 have loadings larger than 0.5. The largest loadings in order of importance follow: sodium, chloride, sulfate, soluble reactive phosphorus, calcium, total dissolved phosphorus, potassium, magnesium, alkalinity, TDS and nitrite+nitrate. Of these parameters, calcium, sodium, chloride, nitrite+nitrate, and sulfate have larger concentrations in WWTP associated samples then in samples associated with poultry waste.

Because of the chemical and bacterial comparison discussed above, PC1 has been identified as associated with poultry waste and PC2 has been identified as associated with WWTP effluent. These identification were be confirmed by the spatial analysis discussed in the next section.

Spatial Analysis

The spatial/temporal analysis evaluated principal component scores in relation to the location of the sample (distance from sources), group type or environmental component (e.g, edge of field), sample conditions (e.g., high flow, base flow), poultry house density, and reference locations.

Appendix F provides the PC1 scores for the surface water samples (SW3) sorted from high to low values. The following observations can be made:

- The highest PC1 scores are the edge of field samples collected as runoff from fields with poultry waste application. Of the top 50 samples with highest PC1 scores (scores above a value of 2), 44 are edge of field samples. Four other samples in this group were collected at USGS stations or small tributarties stations during very high flow conditions. The highest PC1 score is 8.1 for an edge of field sample collected after documented poultry waste application and from water flowing off the field. The fact that the highest PC1 scores are from the edge of field samples is consistent with the samples being collected at the source of surface water contamination; i.e., the runoff from fields with poultry waste. These are the locations where the most PC1 parameters were detected at the highest concentrations.

- The lowest scores are from reference areas or areas with minimal poultry houses and operations. The lowest score (1.00) is from REF2 (Dry Creek), the only true reference with no poultry houses in the area. Other "reference" locations outside the IRW, REF1 and REF3 (Little Lee Creek and Spring Creek) have the third and fifth lowest PC1 scores, respectively (1.18 and 1.19). Other low scores were from samples collected at HFS30 and HFS28A which are small tributarties in the IRW with low poultry house density. Some low scores were also observed for some USGS stations on the Baron Fork and HFS20. HFS20 has low poultry house density in the actual basin, but high poultry house density within a two mile radius. If PC1 represents poultry contaminant, then areas with minimal poultry impacts should have the lowest PC1 scores.

- **Figures 6.11-22a and 6.11-22b** show box plots with the median, lower quartile and upper quartile for the PC1 scores for the following groups: edge of field samples, small tributartiy locations with samples collected at high flow, small tributarty locations with samples collected at base flow, USGS stations (at high flow), USGS stations (base flow), surface water samples collected at biological and other river locations (mostly base flow), samples collected in Lake Tenkiller and samples collected at reference or locations with minimal poultry waste impact. As shown the median and upper quartile PC1 scores typically decrease in value in a logical order according to the known pathways from very high at the edge of field to very low at the reference locations. After edge of field samples, samples collected during high flow conditions in the small tributarties have the next highest scores followed by base flow samples collected at the same locations and surface water samples collected at high flow conditions. The median PC1 score for USGS samples collected at high flow show an increase compared to the median for surface water samples collected for other river samples. The PC1 scores for samples collected from Lake Tenkiller are higher than the PC1 scores for samples collected at the USGS stations during base flow conditions. The reference areas have the lowest PC1 scores. This evaluation shows the transport of PC1 parameters from the edge of field to rivers and streams and finally to Lake Tenkiller.

Appendix F shows the PC2 scores sorted from the highest to lowest scores for run SW3. Several observations can be made:

- Of the highest 65 PC2 scores (above PC2 values of 4.8), three are discharge samples from WWTPs, 52 are surface water samples and 10 are the anomalous EOF samples discussed in Section 6.8. Of the 52 surface water samples, 48 are downgradient of WWTP discharges. This includes 18 samples at HFS04 (downgradient of Siloam Springs WWTP discharge) and 16 samples at HFS22 (downgradient of Lincoln WWTP discharge). Samples from locations 345, 121, 75, 349, 31, 350, 901, 120, 109, 72, 122 and 246 are also in this group. These samples are downgradient of discharges from Rogers, Springdale, Siloam Springs, Prairie Grove, Lincoln, Westville and Fayetteville WWTP discharges. Most of the samples are downgradient of Springdale or Rogers. See **Table 6.11-11** for the largest PC2 scores and locations.

- Of the highest 65 PC2 scores, 10 are from edge of field samples. However the chemical/bacterial compositions of these 10 samples are distinctly different than effluent from WWTPs and are discussed in detail in Section 6.8. These 10 samples also have very high PC1 while the WWTP impacted samples do not have high PC1 scores. These 10 samples are not WWTP effluent impacted but are thought to be fresh leachates collected during very high runoff conditions. These samples could potentially contain both cattle manure and poultry waste contamination.

Summary Observations

Because of the spatial analysis and comparisons to waste compositions, PC1 has been identified as related to poultry contamination (i.e., a poultry waste signature) and PC2 has been identified as related to WWTP discharge (i.e., a WWTP signature). In addition, high PC1 scores are observed along the major flow pathways and are higher near sources of poultry waste land application and decrease with distance from the source areas. The evaluation of these observations is performed in conjunction with the next two Steps of the PCA evaluation: step 13 (Use of PC Scores to Determine Sample and Locations Impacted by Major Sources of Contamination) and step 14 (Investigative and Sensitivity Runs).

Step 13: Use the PC Scores to Determine the Samples and Locations in the IRW that are Impacted by Major Sources of Contamination

As previously discussed in Step 12, a spatial evaluation was performed to evaluate the individual sample PC scores in relation to distance from sources, sample group, sample conditions and reference locations. In this step the individual PC scores were evaluated to determine the magnitude of impact or contamination from sources across the basin. If contamination is pervasive and dominant across the IRW in all environment components, a pattern or signature groups of each major source of contamination should be observed when evaluating PC scores relative to each other.

Figures 6.11-18a and 6.11-18b provides a plot of the PC1 (x-axis) vs the PC2 (y-axis) scores for run SW3. **Figure 6.11-f** shows all 573 scores and **Figure 6.11-18b** shows only the scores for the samples inside the box shown in **Figure 6.11-18a** ("Area of Expanded View"). **Figure 6.11-18c** shows all points in the expanded view area (560 out of the 573 samples are shown). The figure also shows lines around the two major groups of samples identified from PC1 and PC2 evaluations. The group with high PC1 scores is labeled "poultry dominant impact" and contains the samples whose chemical and bacterial composition is dominated by poultry contamination. The group with high PC2 scores is labeled "WWTP dominant impact". These are the samples in which the WWTP impact or influence on the sample is greater than the poultry impact. There are 57 samples in this group (10 % of total). It is important to note that except for some of the reference samples, most of the samples (even those "dominated" by WWTP) show some poultry contamination.

The two groups were selected by examining the locations and chemistry/bacterial composition of the individual samples. For the "WWTP dominant impact" group, the PC2 scores were selected to be above a value of 4.7. As shown in **Table 6.11-11**, samples below about a score of 4.8 are typically not in locations downgradient of WWTP discharges so cannot be impacted by WWTPs. For the "poultry waste dominant impact" group, a PC1 score of greater than 1.3 was selected. This is a conservatively high value and could have been set lower to include more samples. The value was selected by examining the locations and scores of samples, particularly the scores of reference samples and samples in low poultry density areas. In summary, the samples with PC1 scores below approximately 1.3 include all samples from reference locations (six total), 9 out of 10 samples from HFS30 (small watershed location with low poultry house density) and 10 out of 11 samples from HFS28A (small watershed location with low poultry house density). The one sample from HFS30 and the one sample from HFS28A with higher PC1 scores were collected during extreme flow events. Overall, 441 of the 573 samples (77%) had PC1 scores higher 1.3 and show some poultry contamination.

Figure 6.11-23 shows the average PC1 scores by location (based on PCA run SW3). The average PC1 score was determined if multiple samples were collected and contained in the PCA analyses by calculating the mean score of those samples. In **Figure 6.11-23**, there are 175 different locations. Of these, 137 have a PC1 average scores greater than 1.3. Therefore, approximately 78 percent of the locations sampled in the IRW show some poultry contamination. Locations with PC2 scores higher than 1.3 are shown in red; those with scores less than 1.3 are shown in green.

The following table gives a breakdown of the number of samples with poultry contamination by the various sample types (based on run SW3):

Sample Type	Sample Counts	Percent > 1.3
EOF	65/65	100
Lake Tenkiller	29/29	100
Steam – base flow	56/90	62
Stream -high flow	13/20	65
Small Trib-base flow	32/48	67
Small Trib-high flow	158/177	89
USGS – base flow	32/48	67
USGS – high flow	60/81	74

Note: the three WWTP discharges samples are not included because they are actual source samples; reference samples are included in the "streams" group.

Evaluation of Groundwater and Spring Samples

Figures 6.11-19a and 6.11-19b show the PC1 score vs PC2 score plot for PCA run SW17. This run is the same as SW3 except groundwater samples (geoprobe and existing wells) and springs samples are included in the PCA. This results in 699 total samples in the PCA. The results of this run are provided graphically and include:

- **Figures 6.11-3** and **6.11-4:** Scree Plots and Variance Analysis
- **Figures 6.11-12** and **6.11-13**: PC Parameters, Loadings and Coefficients

- **Figures 6.11-19a, b, c** and **d**: PC1 vs PC2 plots

In addition, **Figure 6.11-22c** provides box plots showing the PC1 scores for geoprobe samples, spring samples and existing well samples (run SW17). As shown, there is a decrease in the median PC1 values with Geoprobe samples having the highest PC1 scores, than springs and existing wells have the lowest PC1 scores. This is a logical progression from shallow alluvial water to springs and to deeper wells.

A similar evaluation of PC1 scores was performed for the SW17 run as for the SW3 run where the PC scores for reference samples and samples from locations in areas of low poultry house density were evaluated. This resulted in determination that the same threshold PC1 score could be used to determine poultry waste impact (samples with PC1 > 1.3). The locations of the springs, wells and geoprobes with PC1 average values above and below a value of 1.3 are shown in Figure 6.11-24 (based on PCA run SW17). There are 112 locations on the figure and 51 have PC1 values of greater than 1.3 (red dots). These locations are impacted with poultry contamination (46 percent). The following table shows the number of individual samples with poultry contamination (run SW17):

Sample Type	Sample Counts	Percent > 1.3
Geoprobe	16/17	94
Springs	19/49	39
Existing Wells	24/60	40

Overall, 59 out of 126 geoprobe, springs and well samples (47%) show poultry contamination. The three wells known to be greater than 150 ft in depth (actual depth = 203 to 803 ft) did not show poultry waste contamination. Four of the grower's wells (unknown depth) did show poultry waste contamination. Sample locations with PC1 scores reflecting poultry waste contamination are located through out the Oklahoma portion of the IRW (most all sample locations where in Oklahoma) and demonstrate that contamination is widespread for residential wells and alluvial groundwater.

In addition to the samples showing poultry waste impact, some of the groundwater samples have higher PC2 scores than the typical samples identified as being impacted with poultry waste contamination (relatively lower PC2 scores). These groundwater samples potentially show human waste impact. Overall about 20 wells may show potential human impact.

Evaluation of Potential Impact of Cattle Manure

The potential impact due to cattle manure was previously discussed in Section 6.4.2. These mass balance calculations indicate that any impact or contamination from cattle manure would be small (typically < 10 percent of the mass for most chemical constitutents) compared to the impact due to poultry waste disposal. Previous steps n this subsection (i.e., step 12 discussing waste characteristics) show that cattle manure and cattle manure leachate are very different in chemical composition when compared to poultry waste and poultry waste leachate. Therefore if cattle waste provides a major impact on contamination in the IRW, a dominant signature should be observed in the PCA. To assist in this evaluation, samples with known cattle contamination were evaluated. The chemical and bacterial compositions of these samples have been previously provided in **Tables 6.11-10 and 6.4-2a)**. The four samples documented with cattle contamination are: SPR-LAL16-SP2, SPR-26, EOF-CP-1B and EOF-CP-1A. **Figure 6.11-25** shows the PC1 vs PC2 score plot for PCA run SW22 (surface water and springs; same as SW3 with springs added). Also shown on this figure are the locations of the four samples with potential cattle contamination (red dots). One of the spring samples (SPR-26) plots in the WWTP impact area and another spring sample (SPR-LAL16-SP2) plots above the WWTP impact area. Field notebooks indicate that SPR-LAL16 was definitively contaminated with cattle manure while SPR had the potential for cattle contamination. The other two samples plots near the edge of the poultry waste impacted area. These four samples have very different PC scores and no consistent relation or group is observed in the PCA. If cattle contamination contributed a significant impact to contamination in the IRW, a clear signature and associated group should be observed in the PCA and the four samples with cattle contamination would be in the group. Based on the mass balance calculations, the comparison of chemical composition and the PCA analyses, cattle waste is not a major source of chemical contamination in the IRW.

Evaluation of Solid Samples

As previously discussed in Step 12 and shown in **Figure 6.11-20a**, cattle manure and poultry waste samples form two distinct groups (PCA run SD1, varimax rotation). In addition, soil samples (0-2 inches) collected from poultry waste applied fields and sediment samples are typically more closely related to poultry waste samples than to cattle manure samples. This shown in **Figure 6.11-20e** (run SD1, varimax, PC2 vs PC3) where the cattle waste is distinct from the soils and sediments samples. The poultry waste samples are closely related the soil and sediment samples.

Both PC1 and PC2 have high loading parameters that are related to poultry waste contamination. **Figures 6.11-20a, b, c** and **d** provide the PC1 vs PC2 plots of run SD6 (solid samples including Lake Tenkiller core samples, no rotation). **Figures 6.11-20b** and **6-11-20d** show an expanded view of the PC1 vs PC2 plots. The core samples typically show a decrease in PC2 scores from the shallow (more contaminated samples) to the deeper (less contaminated samples). As has been previously discussed (see section 6.7.2), this contamination in the Lake Tenkiller core samples is the result of poultry waste. As shown **Figures 6.11-20b** and **d**, these contaminated core sample plot with most of the soil and other sediment samples collected from the IRW.

Step 14: Perform Investigative and Sensitivity Analyses

Analyses were performed to evaluate the change in the PCA results due to various database selections or to determine the "sensitivity" of the results due to change in various elements of the PCA. In particular the change was evaluated by comparing the PCA results between various PCA runs. The results evaluated included comparison of the magnitude of the parameter coefficients, the percent variance explained and the PC scores for the individual samples. Changes made in the PCA runs included the number of parameters, specific parameters (e.g., arsenic and nickel), the groups or types of samples from environmental components (e.g., combinations of different environmental components), types of analyses (e.g., various forms and analytical methods for phosphorus) and specific samples (e.g., outliers).

In particular, the following sensitivity runs were previously performed:

- Surface water samples with and without additional phosphorus parameters. Retention of three form of phosphorus may be redundant and bias result to those samples with phosphorus. Similar runs were also performed for this current report.

- Surface water samples with and without the following parameters: arsenic, nickel, nitrate+nitrite and alkalinity. These were the parameters which were on the border line based on the parameter selection criteria (step 8). These parameters were all retained for the current runs in this report.

- Surface water samples using only parameters with highly positive coefficients (17 parameters with loadings > 0.5). This run was performed to determine the effect on variance. Although the amount of variance related to PC1 and PC2 increased, the ability to distinguish groups of potential contamination impact were not as distinct. For the current report, the practice of using as large amount of parameters as possible was continued.

- Surface water samples with and without base flow distinguished from high flow samples. These runs were performed to determine differences in impact at high flow and base flow as observed in the scores and evaluate any bias of sampling during high flow. In this current report, all surface water samples are designated as either high flow or base flow samples.

- Surface water samples without edge of field samples. This run was performed to determine the influence of edge of field samples on the results. This run was also performed for the current report.

- Surface water samples without the samples with the highest 22 PC1 scores. This run was performed to determine the influence of samples with high concentrations.

- Surface and groundwater samples with and without additional phosphorus parameters. As above, this run was performed to determine the influence of using three forms of phosphorus.

- Surface and groundwater samples with and without samples with the highest 22 PC1 scores.

- Surface and groundwater samples with the phosphorus (4500PF) results replaced with dissolved phosphorus (6020) and total metals replaced with dissolved metals for geoprobe samples. This replacement provides lower values for the phosphorus and metal concentrations. The geoprobe sample typically had high turbidity (geoprobes are not developed similar to wells) and therefore, total concentrations are elevated. These substitutions were continued for the current report.

- Surface and spring samples only. This was performed to see the scores and influence of springs with observed or potential cattle contamination. This run was also performed for the current report.

As a result of the previous PCA runs, the evaluations for this report also included a series of investigative and sensitivity runs. These various runs are summarized in Table 6.11-7 (see last column for purpose) and discussed in the following paragraphs:

- A series of PCA runs were conducted to evaluate the sensitivity on the water PCA of using total versus dissolved metals concentrations: SW 1 versus SW 2, SW 3 versus SW 4, SW 5 versus SW 6, SW 7 versus SW 8, SW 9 versus SW 10, SW 11 versus SW 12, and SW 13 versus SW 14. These runs were conducted under a variety of other sensitivity conditions (discussed below). In all of these runs, changes in the PCA results were observed to be minor; i.e., the results were similar whether total or dissolved metals were used. Although similar, the PCA runs with total metals did exhibit a generally stronger relationship or ability to characterize waste source signatures in the watershed. This was reasonable because the impacts were expected to be more significant during high flow conditions.

- A series of PCA runs were conducted to evaluate the sensitivity on the water PCA, and on the solids PCA, of allowing missing data in the calculation of PC scores versus not allowing any missing data: SW 3 versus SW 15, SW 16 versus SW 17, SD 1 versus SD 2, SD 3 versus SD 4, and SD 6 versus SD 7. These runs were conducted under a variety of other sensitivity conditions (discussed below). In all of these runs, changes in the PCA were either observed to be minor, or the results were similar between corresponding samples. Although similar, the PCA runs that allowed for relatively larger amounts of missing data did provide relatively more information (more sample PC scores) for purposes of evaluating waste source signatures in the watershed.

- A series of PCA runs were conducted to evaluate the sensitivity on the water PCA of using one phosphorus variable versus using three (possibly redundant) phosphorus variables, in conjunction with the sensitivity of using a single bacteria variable versus using multiple bacteria variables: SW 7 versus SW 8 (one versus three phosphorus variables), SW 9 versus SW 10 and SW 11 versus SW 12 (one versus multiple bacteria variables), and SW 13 versus SW 14 (combination of one versus three phosphorus, and one versus multiple bacteria). In addition, these runs were conducted with total versus dissolved metals (discussed above). The runs using a single bacteria versus multiple bacteria variables was conducted to test the possible impact on the PCA of multiple bacteria all with high concentrations. In all of these runs, changes in the PCA were either observed to be minor, or the results were similar between corresponding samples. Although similar, the PCA runs that included all three forms of phosphorus, and that included multiple bacteria variables, did exhibit a generally stronger relationship or ability to characterize waste source signatures in the watershed.

- A series of PCA runs were conducted to evaluate the sensitivity on the water PCA of including SPLP leachate data and/or edge-of-field data versus not including these data: SW 1 versus SW 3, SW 2 versus SW 4, SW 3 versus SW 5, and SW 4 versus SW 6. These runs were conducted to investigate the relative impact on the PCA of including samples with much higher overall concentrations, i.e., potentially more indicative of poultry and cattle impacts. In all of these runs, including these data generally enhanced the ability to evaluate waste source signatures in the watershed. However, the SPLP samples had a significant impact on the PCA results, essentially overwhelming all other sample results and decreasing the ability to distinguish source impact in ambient surface waters of the IRW. Therefore, these runs indicated that including the SPLP data was not representative of actual source impact conditions in the watershed. Additional PCA runs were conducted to further evaluate differences between SPLP and edge-of-field samples only. These runs: SW 16, SW 17, SW 18, SW 19, SW 20, and SW 21, which were considered more "investigative" in nature, provided further support for excluding the SPLP data in the selection of the most important runs for evaluating source signatures.

- A series of PCA runs were conducted to evaluate the sensitivity or influence on the water PCA of including groundwater and/or spring sample data versus not including these data: SW 3 versus SW 16, SW 17, and SW 18. These runs were conducted to evaluate the relative impact on the PCA of including samples (homeowner groundwater) with much lower overall concentrations. In all of these runs, including these data did not negatively impact the ability to evaluate waste source signatures in the watershed. In certain cases, the inclusion of these data, especially the spring samples, was useful in interpreting or explaining certain apparently anomalous results.

- A series of PCA runs were conducted to evaluate the sensitivity on the solids PCA of including poultry waste and cow manure sample data versus not including these data: SD 1 versus SD 3, and SD 2 versus SD 4. Similar to the SPLP leachate and edge of field water sensitivity runs, these runs were conducted to investigate the relative impact on the solids PCA of including samples with much higher overall concentrations, i.e., potentially more indicative of poultry and cattle impacts. In all of these runs, including these data generally enhanced the ability to evaluate waste source signatures in the watershed.

- Additional solids PCA runs were conducted to evaluate the impact on the PCA of including Lake Tenkiller core samples versus not including these samples: SD 1 versus SD 6, SD 7, and SD 8. In addition, an investigative PCA run using only Lake Tenkiller core samples was conducted: SD 5. All of these runs were used to evaluate whether the core samples could be included in the PCA without loss of information and without biasing the results, due to the fact that the core samples were necessarily analyzed for a smaller set of variables (limited amount of material was available for analysis). The results indicated that including the core samples supplied additional information relevant to the evaluation of waste source signatures in the watershed.

The above sensitivity runs relate to the current PCA runs conducted and discussed in this report. However, in addition to these current runs, numerous sensitivity runs were also conducted during previous, preliminary PCA runs. As discussed above, many of these previous runs were repeated in the current runs and are therefore not discussed specifically in this report. On the other hand, some of these previous runs were not repeated, including, for example, the sensitivity on the water PCA of including arsenic and nickel data versus not including these data.

In summary, the sensitivity analyses indicated that the PCA (as established and conducted in this investigation) proved to be very robust and was insensitive to changes in variables, groupings, or other conditions. The PCA is an appropriate method to identify major sources of contamination in the IRW.

Step 15: State and Document Conclusions

Overall, PCA supports the other lines of evidence previously discussed in this section. Major conclusions from the PCA follow:

- PCA identified two major sources of contamination in the IRW: poultry waste disposal and WWTP discharges. Poultry waste is by far the dominant contamination source in the IRW when compared to other sources. Cattle waste contamination was unique from both poultry waste and WWTP discharges; however, contamination from cattle waste is not dominant in the IRW and only represents a minor source.

The overall conclusions of the PCA evaluation in relation to the hypotheses given in section 6.1 follow:

- Land application of poultry waste affects the chemical and bacterial water and sediment composition of the IRW. The affect is observable in surface water, groundwater and sediments collected from the IRW. This is shown by PCA: a large and distinct group of samples is dominated by poultry waste contamination.

- WWTP discharges into rivers affect the chemical and bacterial water composition of the IRW. The affect is observable in surface waters collected from the IRW. This is shown by PCA: a distinct group of samples is dominated by WWTP discharge.

- Cattle manure deposited in fields and rivers affects the chemical and bacterial composition; however, no dominant impact is observed from cattle waste in the PCA. This is consistent with the mass balances.

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6.~~11.3~~ Conclusions

As discussed in Section 6.2, multiple lines of evidence were used to evaluate the sources of contamination in the IRW. The multiple lines of evidence all support that poultry waste disposal by land application is a major source of contamination including phosphorus and bacteria in the IRW. These lines of evidence include the chemical and bacterial composition of major waste sources compared to contamination in the IRW, mass balance calculations showing that poultry waste is a major source of contamination, fate and transport observations for poultry waste contaminants through out the IRW, analyses and detection of a poultry specific biomarker and PCA evaluations showing poultry waste contamination in a dominant source. These lines of evidence can be used to test the hypotheses stated in Section 6.1. The conclusions concerning the hypotheses follow:

- Land application of poultry waste affects the chemical and bacterial water and sediment composition of the IRW and the affect is observable in surface water, groundwater and sediments collected from the IRW. Poultry waste is the dominant source of contamination in the IRW.

- WWTP discharges into rivers affect the chemical and bacterial water composition of the IRW. The affect is observable in surface waters collected from the IRW. The effect is not as large as the effect of poultry waste disposal in the IRW.

- Cattle manure deposited in fields and rivers affects the chemical and bacterial composition; however, no dominant impact is observed from cattle waste in the PCA.

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My hourly rate is $260.00/hour

Section 7
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Tables

Table 2.1-1: Summary of Poultry Houses Sampled by Integrator, Grower, Type of Poultry in the House, and Sample Date.

Sample ID	Integrator	Grower	Type of Poultry	Date Sampled
FAC-1A	Simmons	Barney Barnes	Broiler	2/2/2006
FAC-1B	Simmons	Barney Barnes	Broiler	2/2/2006
FAC-1C	Simmons	Barney Barnes	Broiler	2/2/2006
FAC-01	Tyson	Jim Pigeon	Broiler	6/20/2006
FAC-02	Simmons	Juana Lofton	Broiler	6/21/2006
FAC-03	Simmons	Joel Reed	Broiler	7/6/2006
FAC-04	Petersons	Saunders	Broiler	7/12/2006
FAC-05	George's	Franklin Glenn	Broiler	7/13/2006
FAC-06	Tyson - Westville Complex 123	Ken Butler	Broiler	7/20/2006
FAC-07	Tyson	Larry McGarrah	Broiler	8/3/2006
FAC-08	Cargill	Schwabe	Turkey	8/15/2006
FAC-09	Cobb	Anderson	Pullets	8/31/2006
FAC-10	Cobb	Anderson-Chancellor	Pullets	9/22/2006
FAC-11	George's	Morrison Broilers	Broiler	10/17/2007
FAC-12	Tyson	Barney Nubbie	Broiler	11/30/2007
FAC-13	Petersons	O'Leary	Broiler	11/29/2007
FAC-14	Cargill	Masters	Turkey	12/7/2007
FAC-15	Tyson	Butler Green Country Complex No. 9	Broiler	12/12/2007
FAC-16	George's	Ricky Reed	Broiler	12/14/2007
FAC-17	Tyson	Butler Green Country Complex No. 12	Broiler	12/19/2007

Table 2.2-1: Summary of Soil Sampling Locations

Sample ID	Integrator	Grower	Date Sampled
Applied Fields			
LAL-01	Simmons	Barnes - historical	2/2/2006
LAL-02	Simmons	Barnes - compost applied	2/2/2006
LAL-03	Simmons	Non-grower	2/3/2006
LAL-05	Cobb	Anderson & Anderson-Chancellor - Section 30	6/12/2006 - 6/13/2006
LAL-06	Cobb	Anderson - Section 9	6/14/2006 - 6/15/2006
LAL-07	Tyson	Pigeon	6/19/2006 - 6/20/2006
LAL-08	Tyson*	Non-grower	6/19/2006 - 6/21/2006
LAL-09	Simmons	Joel Reed	6/21/2006 - 6/22/2006 & 8/3/2006 (area C)
LAL-10	Tyson	Butler - Westville Complex 123	6/26/2006
LAL-11	Simmons*	Non-grower	6/28/2006 - 6/29/2006
LAL-12	Tyson	McGarrah	7/6/2006 - 7/7/2006
LAL-13	Simmons	Collins - historical	7/6/2006 - 7/7/2006
LAL-14	George's	Glenn	7/10/2006 - 7/11/2006
LAL-15	Petersons	Saunders	7/10/2006 & 7/19/2006
LAL-16	Cargill	Schwabe	7/17/2006 - 7/18/2006
LAL-17	Simmons	Loftin	7/17/2006 - 7/18/2006
LAL-18	Cobb	Anderson - Section 33	8/16/2006 & 8/31/2006 (area D)
LAL-19	George's	Morrison Broilers	10/17/2007 - 10/18/2007
LAL-20	Tyson	Research Farm	11/13/2007 - 11/14/2007
LAL-21	Tyson	Barney Nubbie	12/6/2007 - 12/7/2007
LAL-22	Petersons	Engleman	12/18/2007 - 12/19/2007
LAL-23	George's	Ricky Reed	12/13/2007 - 12/14/2007
Control Fields			
CL-1	N/A	N/A	10/24/2006 - 10/25/2006
CL-2	N/A	N/A	10/24/2006
CL-3	N/A	N/A	12/12/2006
CP-1	N/A	N/A	4/1/2008
CP-2	N/A	N/A	4/2/2008

*Integrators listed for non-growers are from the suspected primary source of waste applied at that location, based on landowner statements.

Table 2.3-1: Summary of Edge of Field (EOF) Run-Off Water Samples Collected

Station ID	Number of Sample Events by Analysis Group					Collection Dates
	Estrogens	Bacteria	Metals	Nitrogens	Phosphorus	
Colcord Field #1			1		1	4/5/2005
Colcord Field #2			1		1	4/5/2005
EOF01	1	1	2	1	2	5/14/2005, 5/23/2005
EOF02		1	2	1	2	5/14/2005, 5/23/2005
EOF03			2	1	2	5/14/2005, 5/23/2005
EOF04			2	1	2	5/14/2005, 5/23/2005
EOF05			2	1	2	5/14/2005, 5/23/2005
EOF06			3	1	3	5/14/2005, 5/23/2005
EOF07	3	2	3	3	3	5/15/2005, 5/23/2005, 6/5/2005
EOF07-222	1	1	1	1	1	4/13/2007
EOF07-230	1	1	1	1	1	4/24/2007
EOF07-232	1	1	1	1	1	4/24/2007
EOF07-259	1	1	1	1	1	4/13/2007
EOF07-LOR#1	1	1	1	1	1	4/24/2007
EOF08	1	1	3	1	3	5/14/2005, 5/23/2005
EOF09	1	1	3	2	3	5/15/2005, 5/23/2005, 6/5/2005
EOF10			1	1	1	5/23/2005
EOF11	1	1	3	2	3	5/23/2005, 6/2/2005, 6/5/2005
EOF12			2	1	2	5/23/2005, 6/1/2005
EOF14	1	1	1	1	1	6/2/2005
EOF15	1	1	1	1	1	6/2/2005
EOF16	1	1	1	1	1	6/5/2005
EOF17	1	1	1	1	1	6/5/2005
EOF18	1	1	1	1	1	6/5/2005
EOF19	1	1	1	1	1	6/5/2005
EOF20	1	1	1	1	1	6/5/2005
EOF21	1	1	1	1	1	6/5/2005
EOF22	1	1	1	1	1	6/5/2005
EOF23	1	1	1	1	1	6/5/2005
EOF24	1	1	1	1	1	6/5/2005
EOF25	1	1	1	1	1	6/5/2005
EOF26	1	1	1	1	1	6/5/2005
EOF27	1	1	1	1	1	6/5/2005
EOF28	1	1	1	1	1	6/5/2005
EOF29	1	1	1	1	1	6/5/2005
EOF30	1	1	1	1	1	6/5/2005
EOF-321		1				3/21/2006
EOF-CP-1A		1	1	1	1	3/31/2008

Table 2.3-1: Summary of Edge of Field (EOF) Run-Off Water Samples Collected

Station ID	Number of Sample Events by Analysis Group					Collection Dates
	Estrogens	Bacteria	Metals	Nitrogens	Phosphorus	
EOF-CP-1B		1	1	1	1	3/31/2008
EOF-EOF1	1	1	1	1	1	6/17/2006
EOF-GF1	1	1	1	1	1	3/9/2006
EOF-SPREAD002	1	1	1	1	1	4/25/2006
EOF-SPREAD007	2	2	2	2	2	4/25/2006, 5/4/2006
EOF-SPREAD010	1	1	1	1	1	5/9/2006
EOF-SPREAD017A	1	1	1	1	1	5/1/2006
EOF-SPREAD023	2	2	2	2	2	4/25/2006, 6/18/2006
EOF-SPREAD025	2	2	2	2	2	5/4/2006, 6/18/2006
EOF-SPREAD026	2	2	2	2	2	4/25/2006, 4/29/2006
EOF-SPREAD029	1	1	1	1	1	4/25/2006
EOF-SPREAD030	1	1	1	1	1	3/31/2006
EOF-SPREAD031	1		1	1	1	4/7/2006
EOF-SPREAD036	1	1	1	1	1	4/25/2006
EOF-SPREAD044	1	1	1	1	1	6/18/2006
EOF-SPREAD048	1	1	1	1	1	5/9/2006
EOF-SPREAD052	1	1	1	1	1	4/25/2006
EOF-SPREAD053B	1	1	1	1	1	5/4/2006
EOF-SPREAD053E	1	1	1	1	1	4/29/2006
EOF-SPREAD053G	1	1	1	1	1	5/4/2006
EOF-SPREAD059	1	1	1	1	1	4/29/2006
EOF-SPREAD060	1	1	1	1	1	4/29/2006
EOF-SPREAD064	1	1	1	1	1	5/4/2006
EOF-SPREAD065	1	1	1	1	1	5/4/2006
EOF-SPREAD068	1	1	1	1	1	6/18/2006
EOF-SPREAD071	1	1	1	1	1	5/10/2006
EOF-SPREAD073B	1	1	1	1	1	6/18/2006
EOF-SPREAD073E	1		1	1	1	6/22/2006
EOF-WF					1	10/25/2007
EOF-ZPEOF001	1	1	1	1	1	4/25/2006
EOF-ZPEOF030	1	1	1	1	1	4/25/2006
SSA01	1		1	1	1	5/14/2005
Total	**63**	**63**	**88**	**74**	**89**	

Table 2.4-1: Summary of Small Tributary Sampling Locations

Site ID	Site Name	Stream Order	Drainage Area (sq miles)	Density of Active Poultry Houses (#/mi2)	USGS Flow Gage	Landuse	Point Sources	Sampling Period
2	Flint Creek at Springtown	3	14.5	2.2	Yes	cropland/pasture, forest	No	2005 – 06
4	Sager Creek near W. Siloam Springs	2	18.3	2.9	Yes	cropland/pasture, residential	Yes	2005 – 06
5	Goose Creek	2	13.9	0.5	No	cropland/pasture, forest	No	2005 – 06
8	N. Trib to Lower Baron Fork	2	11.4	3.3	No	cropland/pasture, forest	No	2005
14	Reference 4 (Trib to Illinois)	2	4.6	0	No	forest, cropland/pasture	No	2005 – 06
16	Tributary to Osage Creek	2	0.8	8.8	No	cropland/pasture	No	2005 – 06
20	Tributary to Cincinatti Creek	2	2.7	15.4	No	cropland/pasture	No	2005 – 06
21	Moores Creek	2	3.6	8.9	No	cropland/pasture, forest	No	2005 – 06
22	Bush Creek	2	3.4	1.8	No	cropland/pasture, forest	Yes	2005 – 06
23	Budd Kidd Creek	2	25.9	1.9	No	cropland/pasture, forest	No	2005 – 06
26	Five Mile Hollow at Flint	2	5.3	0	No	forest	No	2005
28A	Tyner Creek	3	7.1	0.7	No	forest, cropland/pasture	No	2005 – 2006
29	Peacheater Creek	2	3.8	2.6	No	cropland/pasture	No	2006
30	Tributary to Baron Fork	2	4.9	0.6	No	forest	No	2006

Table 2.4-2: Summary of Laboratory Analyses: Small Tributary Sampling

Analysis	Bottle	Preservative	Minimum Volume	Analytical Laboratory	Analytical Method
Total Organic Carbon	2-40-mL glass	HCl	80 mL	A&L	415.2
Total Metals+Mo+P	500-mL poly	HNO3	125-mL	A&L	EPA SW-3050/6010
Dissolved Metals+Mo+P (filtered)	500-mL poly	HNO3	125-mL	A&L	EPA SW-3050/6010
TKN, Ammonia	500-mL poly	H2SO4	225-mL	A&L	TKN, 351.3
Sulfate, Chloride, Alkalinity (filtered)	500-mL poly	None	350-mL	A&L	375.1, 310.2
Nitrate+Nitrite, TSS, TDS, pH	500-mL poly	None	400-mL	A&L	353.3, 160.2, 160.1, 150.0
Total and Dissolved Phosphate, ortho phosphate	150-mL poly	None	100-mL	Aquatic Research	365.2
Estrogens	1000-mL amber glass	H2SO4	1000-mL	GEL	LC-MS-MS
PCR	1000-mL poly sterile	None	1000-mL	Northwind/Idaho State University	qPCR
Bacteria	500-mL poly sterile	None	500-mL	EML	SM-9221B, SM-9221F, SM-9230B, SM-9221F, MPN, MPN, MPN

Table 2.4-3: Summary of Small Tributary Sampling

Year	Sample Sites	Sampling Period	Total Number of Samples Collected	Highflow Events per Site	Baseflow Events per Site
2005	12	5/25 – 10/12	95	0 – 9	1 -4
2006	12	3/9 – 6/30	143	4 – 11	2

Table 2.5-1: Summary of Groundwater Sampling Locations

Station ID	Sample Date	Location Type	Property Owner	Well Depth (Feet)	Drinking Water	Basin Area (sq. miles)	Active Poultry House Density (Houses per sq mile)	Nearest Active House (meters)
GP-GW01	11/27/2006	Geoprobe Location	State/County ROW	3	No	16.4	1.34	2,969
GP-GW06	6/27/2007	Geoprobe Location	State/County ROW	14	No	4.1	0.00	2,051
GP-GW08	11/28/2006	Geoprobe Location	State/County ROW	25	No	5.5	0.36	2,159
GP-GW08	11/29/2006	Geoprobe Location	State/County ROW	25	No	5.5	0.36	2,159
GP-GW09	11/30/2006	Geoprobe Location	State/County ROW	11	No	24.5	0.00	1,152
GP-GW10	11/30/2006	Geoprobe Location	State/County ROW	4	No	8.7	0.35	807
GP-GW14	6/27/2007	Geoprobe Location	State/County ROW	13.6	No	14.8	1.08	972
GP-GW18A	6/26/2007	Geoprobe Location	State/County ROW	16.6	No	11.1	0.54	251
GP-GW19	11/30/2006	Geoprobe Location	State/County ROW	7	No	10.7	2.53	2,045
GP-GW20	11/30/2006	Geoprobe Location	State/County ROW	6	No	10.7	2.53	2,332
GP-GW26	11/29/2006	Geoprobe Location	State/County ROW	15	No	13.4	0.00	6,047
GP-GW29	6/28/2007	Geoprobe Location	State/County ROW	15	No	2.4	0.00	4,708
GP-GW31	6/28/2007	Geoprobe Location	State/County ROW	16.5	No	11.5	0.70	2,502
GP-GW33	6/25/2007	Geoprobe Location	State/County ROW	21.5	No	13.3	2.56	1,364
GP-GW34	6/26/2007	Geoprobe Location	State/County ROW	11	No	13.3	2.56	779
GP-GW36	6/26/2007	Geoprobe Location	State/County ROW	12.7	No	13.3	2.56	533
GP-GW39	6/27/2007	Geoprobe Location	State/County ROW	12.9	No	14.8	1.08	181
GP-GW40	6/27/2007	Geoprobe Location	State/County ROW	14	No	14.8	1.08	126
GP-GW44	12/1/2006	Geoprobe Location	State/County ROW	7	No	17.3	3.76	1,237
GP-GW48	12/1/2006	Geoprobe Location	State/County ROW	11	No	18.3	2.95	1,307
GW-1	7/7/2006	Residential Well	Larry McGarrah	n/a	Unlikely - no evidence of use	17.3	3.76	57
GW-10	7/18/2006	Residential Well	Robert Schwabe	n/a	Unlikely - cattle well	7.6	0.13	632
GW-11	7/19/2006	Residential Well	Rhonda Brown	140	YES	2.4	0.00	522
GW-12	7/12/2006	Residential Well	Sara Blagg	147	Not Specified	9.8	1.94	532
GW-12	7/20/2006	Residential Well	Sara Blagg	147	Not Specified	9.8	1.94	532
GW-13	7/20/2006	Residential Well	Bill Huestis	100	Not Specified	2.9	0.00	528
GW-14	7/12/2006	Residential Well	Judy Bunch	140	Not Specified	2.0	0.00	524
GW-14	7/20/2006	Residential Well	Judy Bunch	140	Not Specified	2.0	0.00	524

Table 2.5-1: Summary of Groundwater Sampling Locations

Station ID	Sample Date	Location Type	Property Owner	Well Depth (Feet)	Drinking Water	Basin Area (sq. miles)	Active Poultry House Density (Houses per sq mile)	Nearest Active House (meters)
GW-15	7/20/2006	Residential Well	Carl Welch	100	YES	2.8	0.00	274
GW-16	7/20/2006	Residential Well	Charlotte Flute	143	Not Specified	16.4	0.00	1,474
GW-17	7/20/2006	Residential Well	Nowell Peteet	n/a	Not Specified	4.0	1.50	809
GW-18	7/20/2006	Residential Well	LeeRoy Christie	124	Not Specified	4.0	1.50	915
GW-19	7/24/2006	Residential Well	Michael Davenport	143	YES	2.4	0.00	1,334
GW-2	7/7/2006	Residential Well	Roger Collins	n/a	No- Former drinking water sources	1.7	7.75	35
GW-21	7/24/2006	Residential Well	Bobby Baird	118	YES	2.4	0.00	1,344
GW-23	7/24/2006	Residential Well	Jim Lingla	120	YES	6.0	0.00	1,394
GW-24	7/25/2006	Residential Well	Michelle Seay	150	YES	18.6	4.19	1,381
GW-25	7/25/2006	Residential Well	Martha Guinn	140	YES	1.9	0.51	1,038
GW-26	7/25/2006	Residential Well	Charles Dye	100	YES	1.9	0.51	997
GW-27	7/25/2006	Residential Well	Mose Killer	80	YES	13.4	0.00	1,372
GW-28	7/26/2006	Residential Well	K. Millican	100	No - Irrigation	2.7	1.88	1,145
GW-29	7/26/2006	Residential Well	Bob Granderson	100	YES	2.7	1.88	1,123
GW-3	7/11/2006	Residential Well	Bev & W.A. Saunders	543	Not Specified	6.2	3.72	1,512
GW-30	7/26/2006	Residential Well	Marlyn Potter	136	YES	3.8	3.20	697
GW-31	8/7/2006	Residential Well	Henry J. Wilson, Jr.	150	YES	4.9	1.83	132
GW-32	8/8/2006	Residential Well	Mitchell Chuculate	100	YES	6.2	0.48	598
GW-32	8/9/2006	Residential Well	Mitchell Chuculate	100	YES	6.2	0.48	598
GW-33	8/9/2006	Residential Well	D. Ellis	n/a	Not Specified	5.0	0.00	1,205
GW-34	8/10/2006	Residential Well	Ronnie Hester	140	YES	11.5	0.70	701
GW-35	8/10/2006	Residential Well	Ronnie Hester	203	No	11.5	0.70	223
GW-36	8/10/2006	Residential Well	Howard Asher	17	YES	8.7	0.35	278
GW-37	8/10/2006	Residential Well	Trey Rogers	100	No- bathing only	16.5	0.24	1,017
GW-38	8/10/2006	Residential Well	Ed Fite	150	YES	1.9	0.00	2,610
GW-39	8/10/2006	Residential Well	Kenneth Oakball	123	Not Specified	5.8	1.72	2,552
GW-40	8/15/2006	Residential Well	Gary Faubian	70	No - Irrigation	16.5	0.24	496
GW-41	8/15/2006	Residential Well	Matthews	75	Not Specified	16.5	0.24	1,470

Table 2.5-1: Summary of Groundwater Sampling Locations

Station ID	Sample Date	Location Type	Property Owner	Well Depth (Feet)	Drinking Water	Basin Area (sq. miles)	Active Poultry House Density (Houses per sq mile)	Nearest Active House (meters)
GW-42	8/17/2006	Residential Well	Dorsey & Jane Brewer	n/a	YES	20.8	0.00	1,153
GW-43	8/17/2006	Residential Well	Dorsey & Jane Brewer	n/a	No - Irrigation	20.8	0.00	1,127
GW-5	7/13/2006	Residential Well	Victor Fleig	110	YES	11.4	3.35	769
GW-50	1/22/2007	Residential Well	Davis Beaver	40	YES	11.1	0.54	822
GW-51	1/22/2007	Residential Well	Paul Igo	120	Not Specified	11.1	0.54	910
GW-52	1/22/2007	Residential Well	Everett Ames	80	Not Specified	5.5	0.36	1,355
GW-53	1/22/2007	Residential Well	Oleta McCoy	100	Not Specified	5.5	3.25	1,182
GW-54	1/23/2007	Residential Well	Vernon Reese	100	Not Specified	13.3	2.56	800
GW-55	1/23/2007	Residential Well	Bobby McAlpine	125	Not Specified	2.2	0.00	1,455
GW-56	1/23/2007	Residential Well	Patsy Madewell	150	Not Specified	4.0	1.50	440
GW-57	1/23/2007	Residential Well	Curtis Kindle	123	Not Specified	5.5	0.36	2,396
GW-58	1/23/2007	Residential Well	Joe Jr. Jones	75	Not Specified	11.8	4.64	342
GW-59	7/30/2007	Residential Well	Bill Ames	75	Not Specified	6.0	0.00	1,419
GW-6	7/13/2006	Residential Well	Barbara Kemper	74	YES	18.6	4.19	651
GW-60	7/10/2007	Residential Well	Sharon Beck	40	Not Specified	1.2	0.00	2,446
GW-61	7/11/2007	Residential Well	Bobby Choate	150	Not Specified	15.4	0.72	521
GW-62	7/11/2007	Residential Well	Josie Scism	85	Not Specified	13.3	2.56	792
GW-63	7/10/2007	Residential Well	Leon Dixon	100	Not Specified	2.3	0.00	2,086
GW-64	6/28/2007	Residential Well	Clouis Kuelbs	120	No - Irrigation and Livestock	4.4	0.23	705
GW-65	7/10/2007	Residential Well	Shawn Kustenborter	103	Not Specified	n/a	n/a	n/a
GW-66	7/10/2007	Residential Well	Darrell Ross	100	Not Specified	13.3	2.56	867
GW-67	7/11/2007	Residential Well	Rhonda Sewell	140	Not Specified	1.2	0.00	3,169
GW-68	7/10/2007	Residential Well	Lester Turner	28	Not Specified	16.4	0.00	1,081
GW-69	7/30/2007	Residential Well	Jason Vance	70	Not Specified	17.0	0.41	1,728
GW-7	7/13/2006	Residential Well	Brenda and Lonnie Thomason	140	YES	18.6	4.19	1,724
GW-8	7/13/2006	Residential Well	Frank Glenn	803	No - Livestock	10.7	2.53	55
GW-9	7/18/2006	Residential Well	Robert Schwabe	n/a	Unlikely - cattle well	8.7	0.35	981

Table 2.6-1: Summary of Spring Sampling Locations and Dates

Station ID	Sample Date	Spring Name	Land Owner	Used for Drinking Water	Basin Area (sq. miles)	Active Poultry House Density (houses per sq. mile)	Nearest Active Poultry House (meters)
SPR-001JBF050806	6/27/2006		Delia M. Kindle		4.9	0.20	2,992
SPR-001RPH051806	6/27/2006				0.0		1,044
SPR-002RPH051006	6/27/2006		Steve Whitmire		3.2	0.63	1,455
SPR-002X-060706	6/7/2006				8.3	0.00	2,541
SPR-004RPH051806	6/27/2006		Brian & Sandy Shacklerford		0.0		703
SPR-005RPH051206	6/27/2006		Tera Gebhart		9.8	1.94	1,821
SPR-005RPH051806	6/27/2006		Walter Duncan		0.0		3,624
SPR-012RPH051206	6/6/2006		Darrel Abshier		17.0	0.41	635
SPR-04	5/25/2005	Anderson Spring			6.5	2.47	697
SPR-07	6/14/2005	Black Fox Springs			8.7	0.35	225
SPR-07	6/7/2006	Black Fox Springs			8.7	0.35	225
SPR-14	5/24/2005	Dripping Springs			5.5	0.73	1,235
SPR-14	6/27/2006	Dripping Springs			5.5	0.73	1,235
SPR-16	5/25/2005	Elm Springs			9.5	3.89	687
SPR-16	6/28/2006	Elm Springs			9.5	3.89	687
SPR-18	5/25/2005	Goad Springs			9.1	2.43	327
SPR-23	6/16/2005	July Spring	V. Potter	Yes	16.4	0.00	1,721
SPR-23	10/12/2005		V. Potter	Yes	16.4	0.00	1,721
SPR-23	6/27/2006		V. Potter	Yes	16.4	0.00	1,721
SPR-24	6/16/2005	Keys Spring			20.8	0.00	241
SPR-24	10/12/2005	Keys Spring			20.8	0.00	241
SPR-24	6/6/2006	Keys Spring			20.8	0.00	241
SPR-25	6/16/2005	Kirk Springs			5.9	0.00	2,788
SPR-25	10/12/2005				5.9	0.00	2,788
SPR-25	6/7/2006				5.9	0.00	2,788
SPR-26	5/26/2005	Living Waters Spring			9.0	2.22	481
SPR-26	6/28/2006	Living Waters Spring			9.0	2.22	481
SPR-27	5/24/2005	Logan Spring			14.9	2.22	544

Table 2.6-1: Summary of Spring Sampling Locations and Dates

Station ID	Sample Date	Spring Name	Land Owner	Used for Drinking Water	Basin Area (sq. miles)	Active Poultry House Density (houses per sq. mile)	Nearest Active Poultry House (meters)
SPR-27	10/11/2005	Logan Spring			14.9	2.22	544
SPR-27	6/28/2006	Logan Spring			14.9	2.22	544
SPR-28	5/25/2005	Osage Spring			16.8	1.25	1,754
SPR-28	6/28/2006	Osage Spring			16.8	1.25	1,754
SPR-32	6/2/2005	Salem Springs			2.5	10.62	271
SPR-32	10/11/2005	Salem Springs			2.5	10.62	271
SPR-32	6/28/2006	Salem Springs			2.5	10.62	271
SPR-36	6/2/2005	Tyler Spring			6.4	0.00	1,639
SPR-36	6/27/2006	Tyler Spring			6.4	0.00	1,639
SPR-48	5/26/2005				1.5	4.13	531
SPR-48	10/11/2005				1.5	4.13	531
SPR-48	6/28/2006				1.5	4.13	531
SPR-61	5/25/2005	Debby Hugues Spring			3.3	1.54	353
SPR-61	10/11/2005	Debby Hugues Spring			3.3	1.54	353
SPR-61	6/28/2006	Debby Hugues Spring			3.3	1.54	353
SPR-62	6/2/2005	Spring seep Limestone			16.4	0.00	1,612
SPR-63	6/1/2005	Davis Spring			3.8	3.42	113
SPR-63	6/7/2006	Davis Spring			3.8	3.42	113
SPR-65	6/14/2005				8.3	0.00	2,575
SPR-65	10/12/2005				8.3	0.00	2,575
SPR-Anderson	6/13/2006	Anderson Spring 1	Bill Anderson	Yes	10.7	2.53	484
SPR-Fite 500	8/10/2006	Fite Spring 1	Fite	No	1.9	0.00	3,875
SPR-Fite 501	8/10/2006	Fite Spring 2	Fite	No	1.9	0.00	3,873
SPR-Hester	6/8/2006	Hester Spring 1	Ronnie Hester	No	11.5	0.70	652
SPR-Jones	1/23/2007	Joe Jones Jr.	Joe Jones	No	13.3	2.56	146
SPR-LAL15SP2	7/11/2006		Bev & W.A. Saunders	No	6.2	3.72	1,751
SPR-LAL16-SP1	7/18/2006		Robert Schwabe	No	7.6	0.13	1,061
SPR-LAL16-SP2	7/18/2006		Robert Schwabe	No	7.6	0.13	458
SPR-VANCE	7/30/2007	Vance Spring 1	Jason Vance	No	17.0	0.41	1,749

Table 2.7-1: Summary of Stream and Small Impoundment Sampling

Station ID	Latitude	Longitude	Waterbody	Sample Collection Date
BS-08	35.79517	-94.84580	Caney Creek	8/23/2005
BS-117	36.02507	-94.32159	Illinois River	9/14/2005
BS-208	35.97317	-94.67706	Peacheater Creek	9/1/2005, 10/12/2005
BS-28	35.90448	-94.62292	Peavine Creek	8/23/2005, 10/12/2005, 11/15/2005
BS-35	35.87241	-94.45710	Fly Creek	9/22/2005, 10/13/2005, 11/15/2005
BS-62A	36.08741	-94.58895	Ballard Creek	8/16/2005, 8/24/2005, 9/22/2005
BS-68	36.09154	-94.50596	Cincinnati Creek	8/19/2005, 8/24/2005
BS-HF04	36.20151	-94.60464	Sager Creek	8/17/2005, 8/24/2005
BS-HF22	35.91576	-94.43543	Bush Creek	8/25/2005
BS-HF28A	36.02831	-94.72511	Tyner Creek	8/18/2005 ,8/23/2005
BS-REF1	35.65246	-94.62246	Little Lee Creek	8/18/2005 ,8/30/2005
BS-REF2	35.99961	-92.72758	Dry Creek	8/31/2005
BS-REF3	36.14498	-94.90716	Spring Creek	8/18/2005, 9/1/2005
HFS-04	36.20174	-94.60510	Sager Creek	10/11/2005
HFS-05	36.05633	-94.29074	Goose Creek	10/11/2005
HFS-08	35.95885	-94.63788	Green Creek	10/12/2005
HFS-16	36.24004	-94.23841	Puppy Creek	8/27/2005, 10/11/2005
HFS-26	36.19498	-94.72543	Flint Creek Tributary	10/11/2005
RS-3	35.92308	-94.92347	Illinois River	10/12/2005
SD-006	35.84148	-94.77278	Caney Creek	4/20/2005
SD-008	35.84802	-94.68690	Caney Creek	4/20/2005, 10/12/2005
SD-010	36.20256	-94.60653	Sager Creek	3/1/2005
SD-012	35.86813	-94.89760	Baron Fork Creek	3/3/2005
SD-016	35.91518	-94.82123	Wall Trip Branch	3/1/2005
SD-024	36.00252	-94.63521	Peacheater Creek	3/3/2005
SD-025	35.94779	-94.68910	Baron Fork Creek	3/3/2005
SD-027	35.91983	-94.62048	Baron Fork Creek	4/19/2005, 10/12/2005
SD-028	35.89365	-94.62828	Peavine Creek	3/3/2005
SD-029	35.87495	-94.56977	Evansville Creek	4/19/2005, 10/12/2005
SD-031	35.90578	-94.51697	Baron Fork Creek	4/20/2005, 10/11/2005
SD-032	35.88002	-94.48724	Baron Fork Creek	3/2/2005
SD-033	35.89825	-94.44724	Baron Fork Creek	3/2/2005, 10/13/2005
SD-035	35.86872	-94.40340	Fly Creek	3/2/2005
SD-037	35.89190	-94.95575	Tahlequah Creek	3/1/2005
SD-039	35.92283	-94.92385	Illinois River	3/1/2005
SD-046	35.96550	-94.91082	Illinois River	3/1/2005
SD-051	36.09960	-94.82505	Illinois River	3/1/2005
SD-057	36.21700	-94.60380	Flint Creek	3/1/2005, 10/11/2005

Table 2.7-1: Summary of Stream and Small Impoundment Sampling

Station ID	Latitude	Longitude	Waterbody	Sample Collection Date
SD-059	36.25580	-94.43374	Flint Creek	3/1/2005
SD-061	36.12962	-94.57223	Illinois River	3/3/2005, 10/13/2005
SD-062	36.04408	-94.56815	Ballard Creek	3/3/2005, 10/11/2005
SD-062-V1	36.08741	-94.58895	Ballard Creek	10/11/2005
SD-062-V2	36.08741	-94.58895	Ballard Creek	10/11/2005
SD-063	36.01442	-94.54653	Ballard Creek	4/19/2005
SD-064	35.94577	-94.47901	Ballard Creek	3/3/2005
SD-068	36.04103	-94.51307	Illinois River	3/3/2005
SD-071	36.16681	-94.43478	Illinois River	3/4/2005
SD-074	36.19181	-94.38753	Osage Creek	3/4/2005
SD-079	36.19728	-94.33782	Osage Creek	3/2/2005
SD-083	36.25819	-94.31759	Lick Branch	3/2/2005, 10/11/2005, 11/15/2005
SD-084	36.22169	-94.28772	Osage Creek	3/2/2005
SD-086	36.28206	-94.26900	Little Osage Creek	3/2/2005
SD-092	36.23993	-94.23819	Puppy Creek	3/2/2005
SD-094	36.26550	-94.23770	Osage Creek	3/2/2005
SD-095	36.29352	-94.15710	Osage Creek	3/2/2005
SD-096	36.17734	-94.39185	Illinois River	3/4/2005
SD-103	36.11967	-94.14404	Mud Creek	3/3/2005
SD-104	36.10157	-94.34403	Illinois River	3/4/2005
SD-105	36.05853	-94.35086	Muddy Fork Creek	3/3/2005
SD-107	36.01850	-94.37421	Moores Creek	3/3/2005
SD-109	35.99835	-94.42715	Moores Creek	3/3/2005
SD-111	35.97149	-94.33392	Muddy Fork Creek	3/3/2005
SD-112	36.05455	-94.31865	Illinois River	3/4/2005
SD-116	35.95389	-94.24958	Illinois River	3/3/2005
SD-117	35.92015	-94.27319	Illinois River	3/3/2005
SD-201	35.90998	-94.56000	Baron Fork Creek	4/19/2005, 10/12/2005
SD-202	35.81127	-94.55250	Evansville Creek	4/20/2005, 10/12/2005
SD-203	35.80498	-94.49470	Evansville Creek Tributary	4/20/2005, 10/13/2005
SD-203-V1	35.80498	-94.49470	Evansville Creek Tributary	10/13/2005
SD-203-V2	35.80498	-94.49470	Evansville Creek Tributary	10/13/2005
SD-204	35.83135	-94.57498	Evansville Creek	4/20/2005
SD-205	36.10518	-94.56557	Ballard Creek	4/19/2005
SD-206	35.84465	-94.79148	Bidding Creek	4/20/2005
SD-207	35.85538	-94.77525	Bidding Creek	4/20/2005
SD-208	36.02288	-94.61883	Peacheater Creek	4/19/2005
SD-210	36.23423	-94.67092	Flint Creek Tributary	4/18/2005, 10/11/2005, 11/15/2005
SD-211	36.23337	-94.61908	Crazy Creek	4/18/2005

Table 2.7-1: Summary of Stream and Small Impoundment Sampling

Station ID	Latitude	Longitude	Waterbody	Sample Collection Date
SD-212	36.21665	-94.66348	Flint Creek	4/18/2005
SD-213	36.23453	-94.59015	Flint Creek Tributary	4/18/2005
SD-214	36.07117	-94.67695	Tyner Creek	4/19/2005
SD-301	36.00970	-94.81317	Pumpkin Hollow	4/4/2005, 4/20/2005, 10/12/2005, 11/15/2005
SD-302	35.98577	-94.87712	Tully Hollow	4/4/2005, 4/20/2005
SD-303	35.99797	-94.89727	Cedar Hollow	4/4/2005, 4/20/2005
SD-304	35.93965	-92.71375	Bear Creek	6/25/2005
SD-305	35.94017	-92.71090	Bear Creek	6/25/2005
SD-306	35.90700	-92.81987	Calf Creek	6/25/2005
SD-307	35.99867	-92.72732	Dry Creek	6/25/2005
SD-308	36.30720	-92.56793	White River	6/25/2005
SD-S03	35.50765	-94.83299	Sallisaw Creek	3/2/2005
SD-S04	35.55883	-94.73491	Brushy Creek	3/2/2005
SD-S06	35.65622	-94.74656	Sallisaw Creek	3/2/2005
LKSD-1L-A	35.97197	-94.35436	Budd Kidd Lake	3/16/2005
LKSD-1L-B	35.96851	-94.35362	Budd Kidd Lake	3/16/2005
LKSD-2L	36.23973	-94.54564	Flint Creek Lake	3/15/2005
LKSD-3L	36.19702	-94.21931	Lake Elmdale	3/15/2005
LKSD-4L	36.13435	-94.13868	Lake Fayetteville	3/15/2005
LKSD-5L-A	36.13032	-94.56040	Lake Frances	3/16/2005
LKSD-5L-B	36.12357	-94.55654	Lake Frances	3/16/2005
LKSD-6L	36.00328	-94.42197	Lake Lincoln	3/16/2005
LKSD-7L	35.93685	-94.33747	Lake Prairie Grove	3/15/2005
LKSD-8L	36.09172	-94.36685	Lake Weddington	3/16/2005
LKSD-9L	36.22306	-94.54196	Siloam Springs City Lake	3/15/2005
LKSD-S15	35.76354	-94.70832	Stillwell City Lake	3/17/2005

Table 2.8-1: Summary for the 2005 River and Biological Sampling

Station ID	Number of Surface Water Samples by Parameter Group											Biological Samples			Sample Dates
	Bacteria	Chloride	Dissolved Metals	Total Metals	Estrogens	Forms of Phosphorus	Nitrogen Compounds	Sulfate	Total Dissolved Solids	Water Quality Parameters	Total	Fish	Benthic Invertebrates (BMI)	Periphyton	
BS-08	1	1	1	1	1	1	1	1	1		**12**	Yes	Yes	Yes	8/23
BS-117	1	1	1	1	1	1	1	1	1		**12**	Yes	Yes	Yes	9/14
BS-208	2	1	1	1	1	2	1	1	1		**17**	Yes	Yes	Yes	9/1, 10/12
BS-28	2	1	1	1	2	2	1	1	1		**18**	Yes	Yes	Yes	8/23, 10/12
BS-35	3	1	1	1	2	2	1	1	1	1	**23**	Yes	Yes	Yes	9/22, 10/13, 11/15
BS-62A	1		1	1	1	1	1		1		**10**	Yes	Yes	Yes	8/16, 8/24
BS-68	1		1	1	1	1	1		1		**10**	Yes	Yes	Yes	8/19, 8/24
BS-HF04	1		1	1	1	1	1		1		**10**	Yes	Yes	Yes	8/17, 8/24
BS-HF22	1	1	1	1	1	1	1	1	1		**12**	Yes	Yes	Yes	8/24
BS-HF28A	1		1	1	1	1	1		1		**10**	Yes	Yes	Yes	8/18, 8/23
BS-REF1	1	1	1	1	1	1	1	1	1		**12**	Yes	Yes	Yes	8/30
BS-REF2	1	1	1	1	1	1	1	1	1		**12**	Yes	Yes	Yes	8/31
BS-REF3	1	1	1	1	1	1	1	1	1		**12**	Yes	Yes	Yes	9/1

Table 2.8-2: Summary of Site Selection Based on Poultry House Densities During the 2006 River and Biological Program

Quintile	Number of original Sites Selected in each Quintile
1	51
2	52
3	52
4	55
5	44
Large Watersheds	22
No Data	20

Table 2.8-3: Summary of Sites Selected for Intensive Biological Sampling by Field PO4 Quintile

Quintile	Range of Field Measured PO4	Number of original Sites Selected in each Quintile
1	< 0.08	9
2	0.08 - 0.15	12
3	0.15- 0.24	10
4	0.24 - 0.54	17
5	> 0.54	24
note: quintiles created from 194 Phase 1 sampling stations		

Table 2.8-4: Summary of the 2006 River and Biological Program Sampling

Parameter Group	Number of Samples Collected		
	Phase 1	Phase 2	Total
Bacteria	0	50	50
Chlorophyll a	0	72	72
Estrogens	0	37	37
Forms Of Phosphorus	145	72	217
Nitrogen Compounds	145	70	215
Sulfate	0	38	38
Chloride	0	38	38
Dissolved Metals	0	38	38
Total Metals	0	38	38
Total/Dissolved Organic Carbon	17	14	31
Total/Dissolved Solids	0	38	38

Table 2.8-5: Summary of Full Suite Sample Sites by Selection Criteria

Chicken House Quintile	Number of Sites
1	4
2	2
3	5
4	6
5	8
None (large river sites)	10
Field PO4 Quintile	**Number of Sites**
1	5
2	6
3	6
4	9
5	6
Not sampled	3

Note: includes HFS-30 sampled for full suite although not one of the 70 Biological Stations

Table 2.8-6: Summary of the 2007 River and Biological Program Sampling

Parameter Group	Number of Samples collected by Sub-task							Total Number of Samples
	Subtask 1a	*Subtask 1b*	*Subtask 1c*			*Subtask 1d*	*Subtask 2*	
	Pre-survey	Weekly	Intensive	Full Suite	Partial Suite	Biological	Synoptic	
Bacteria				36	2			38
Chlorophyll a, Benthic			414					414
Chlorophyll a, Sestonic			72			38		110
Diatoms			70					70
Benthic Macroinvertebrates			70					70
Estrogens				36				36
Forms Of P		613	70	36	35	37		791
Nitrogen Compounds				36	35	38		109
Chloride				36		38		74
Sulfate				36				36
Dissolved Metals				36				36
Total Metals				36				36
Total/Dissolved Organic Carbon		72	70	36	35	34		247
Total Suspended/Dissolved Solids				36				36
Field PO4 samples	86						99	185

Table 2.10-1: Summary of USGS Sampling Efforts as of 4/30/2008

Station ID	Number of Dates Sampled	Date Ranges	Approximate Number of Samples for Parameter Groups at Each Station									Total
			Bacteria	Chloride	Dissolved Metals	Total Metals	Estrogens	Forms of Phosphorus	Nitrogen Compounds	Sulfate	Suspended Sediment	
07195500	50	04/12/2005 - 04/01/2008	30	22	24	24	29	32	30	22	18	231
07196000	42	04/22/2005 - 04/01/2008	29	24	24	24	21	29	29	24	13	217
07196090	45	04/12/2005 - 04/02/2008	31	23	26	26	27	32	32	23	15	235
07196500	52	04/13/2005 - 04/02/2008	32	25	26	26	28	33	33	25	18	246
07197000	43	04/29/2005 - 04/01/2008	28	24	24	24	24	30	30	24	13	221
07197360	35	07/11/2005 - 03/19/2008	23	19	19	19	19	21	21	19	8	168
07195855	6	10/10/2006 - 08/07/2007						6	6		1	13
07195865	6	10/10/2006 - 08/07/2007						6	6			12

Table 2.11-1: Raw Water Intakes on and Around Lake Tenkiller, Populations Served, and CDM Sampling Summary

System Name	Public Water Supply ID	Source	Residential Population Served	Transient Population Served	Wholesale Population Served	Number of CDM Sampling Events	CDM Station ID	Status
Tahlequah PWA	OK1021701	Illinois River	14458	-	3973	12	RWI-TAHPWA	
Gore PWA	OK1021773	Lake Tenkiller	1688	-	-	15	RWI-GOREPWA	
Cherokee Co RWD #13	OK1021721	Lake Tenkiller	1640	480	-	13	RWI-CHRWD13	
Cherokee Co RWD # 2 (Keys)	OK1021711	Lake Tenkiller	1188	-	51	15	RWI-CHRWD2	
Adair Co RWD #5	OK1021770	Baron Fork Creek	675	275	-	9	RWI-ADRWD5	
LRED (Dutchmans Cabins)	OK1021722	Lake Tenkiller	145	-	-	-	-	Inactive
East Central Okla Water Auth	OK1021713	Lake Tenkiller	1200	-	-	-	-	
Fin & Feather Resort	OK1021730	Lake Tenkiller	150	-	-	2	RWI-FINFEA	
LRED (Chicken Creek)	OK1021707	Lake Tenkiller	272	-	30	-	-	
LRED (Lakewood)	OK1021731	Lake Tenkiller	200	-	50	2	RWI-LREDLW	
LRED (Wildcat)	OK1021703	Lake Tenkiller	200	-	50	-	-	
LRED (Woodhaven)	OK1021727	Lake Tenkiller	200	-	-	2	RWI-LREDWH	
Paradise Hill Water Users Assn	OK1021716	Lake Tenkiller	270	-	-	-	-	Inactive
Pettit Mt Water	OK1021702	Lake Tenkiller	90	-	-	-	-	
Sequoyah Co RWD # 5	OK1021775	Illinois River	1075	-	-	-	-	
Sequoyah County Water Assoc.	OK1020210	Lake Tenkiller, Lee Creek, Roland	13460	-	2259	-	-	
Summit Water Company Inc	OK1021710	Lake Tenkiller	120	-	100	2	RWI-SUMWCI	Inactive
Tenkiller Aqua Park	OK1021745	Lake Tenkiller	150	-	-	2	RWI-TKAP	
Tenkiller Utility Co	OK1021756	Lake Tenkiller	500	-	-	2	RWI-TKUC	
Flintridge RWD	OK1021694	Illinois River, Clear Lake	1300	-	-	-	-	Emergency use only
Tenkiller State Park	OK1021714	Lake Tenkiller	150	-	-	2	RWI-TKSP	Inactive
Burnt Cabin RWD	OK1021763	Lake Tenkiller	118	-	-	-	-	
Burnt Cabin Ridge Water	OK1021757	Lake Tenkiller	-	650	-	-	-	inactive
Cherokee Landing Motel	OK1021754	Lake Tenkiller	-	50	-	-	-	inactive
Cherokee Landing State Park	OK3001117	Lake Tenkiller	-	25	-	-	-	inactive
Cherokee Land Yacht Harbor	OK1021718	Lake Tenkiller	100	-	-	-	-	Inactive
Dept Of Human Services	OK1021752	Lake Tenkiller	400	-	-	-	-	Inactive
Mongolds Water System	OK1021765	Lake Tenkiller	24	-	-	-	-	
Pettit Bay Resort	OK1021755	Lake Tenkiller	-	30	-	-	-	

Table 2.11-2: Summary of Samples Collected During the 2005 Lake Events

Station ID	Approximate Number of Sample Collected for Each Parameter Group at each Site												
	Bacteria	Chloride	Chlorophyll a	Dissolved Metals	Estrogens	Forms Of Phosphorus	Nitrogen Compounds	Sulfate	THM	Total Metals	Total Dissolved Solids	Phytoplankton	Zooplankton
Primary Lake Stations													
LK-01	3	6	46	31	4	78	57	6	-	31	40	16	14
LK-02	3	6	41	30	4	84	60	6	-	30	42	16	14
LK-03	3	6	37	30	3	53	44	6	-	32	41	16	14
LK-04	2	3	17	14	2	22	14	3	-	14	14	11	9
Raw Water Intakes													
RWI-ADRWD5	-	-	-	-	-	-	-	-	5	-	-	-	-
RWI-CHRWD13	1	-	2	-	-	1	-	-	6	-	-	2	-
RWI-CHRWD2	1	-	2	-	-	1	-	-	6	-	-	2	-
RWI-FINFEA	1	-	2	-	-	1	-	-	1	-	-	2	-
RWI-GOREPWA	1	-	2	-	-	1	-	-	6	-	-	1	-
RWI-LREDLW	1	-	2	-	-	1	-	-	1	-	-	2	-
RWI-LREDWH	2	-	2	-	-	1	-	-	1	-	-	1	-
RWI-SUMWCI	1	-	2	-	-	1	-	-	1	-	-	3	-
RWI-TAHPWA	1	-	-	-	-	-	-	-	6	-	-	-	-
RWI-TKAP	1	-	2	-	-	1	-	-	1	-	-	2	-
RWI-TKSP	1	-	2	-	-	1	-	-	1	-	-	1	-
RWI-TKUC	1	-	2	-	-	1	-	-	1	-	-	2	-
Beach Sampling													
SK-LANDINGS-SP	1	-	-	-	-	-	-	-	-	-	-	1	-
TK-SP-BEACH	1	-	-	-	-	-	-	-	-	-	-	1	-
PETTIT BEACH	1	-	-	-	-	-	-	-	-	-	-	1	-
River Inlet Stations													
RS-1	1	2	9	9	1	10	9	2	-	9	9	-	-
RS-2	1	2	9	9	1	10	9	2	-	9	9	-	-
RS-3	1	2	9	9	1	11	9	2	-	9	9	-	-

Table 2.11-3: Summary of Samples Collected During the 2006 Lake Events

Station ID	Approximate Number of Sample Collected for Each Parameter Group at each Site															
	Bacteria	Chloride	Chlorophyll a	COD/BOD	Dissolved Metals	Estrogens	Forms Of Phosphorus	Misc. AAL Data	Nitrogen Compounds	Sulfate	THM	Total Metals	Total Dissolved Organic Carbon	Total Dissolved Solids	Water Quality Parameters	Phytoplankton	Zooplankton
Primary Lake Stations																	
LK-01	5	14	47	38	14	10	87	-	87	14	-	4	30	87	87	17	14
LK-02	5	14	42	39	14	10	87	-	87	14	-	4	30	87	86	13	14
LK-03	5	8	36	15	10	8	35	-	35	8	-	1	16	35	35	14	14
LK-04	5	7	34	14	8	7	34	-	34	7	-	1	16	34	34	14	14
Raw Water Intakes																	
RWI-ADRWD5	-	-	2	-	-	-	-	-	-	-	3	-	-	-	-	-	-
RWI-CHRWD13	-	-	2	-	-	-	-	-	-	-	3	-	-	-	-	-	-
RWI-CHRWD2	-	-	4	-	-	-	-	2	-	-	6	-	-	-	-	-	-
RWI-FINFEA	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-
RWI-GOREPWA	-	-	4	-	-	-	-	2	-	-	6	-	-	-	-	-	-
RWI-LREDLW	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-
RWI-LREDWH	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-
RWI-SUMWCI	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-
RWI-TAHPWA	-	-	4	-	-	-	-	1	-	-	6	-	-	-	-	-	-
RWI-TKAP	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-
RWI-TKSP	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-
RWI-TKUC	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Beach Sampling																	
LK-CB	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-
LK-CLSP	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-
LK-TKSP	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-
River Inlet Stations																	
RS-1	6	4	14	6	5	4	15	-	15	4	-	5	8	14	14	-	-
RS-2	6	4	14	6	5	3	15	-	15	4	1	5	8	14	14	-	-
RS-3	6	4	14	6	5	4	15	-	15	4	-	5	8	14	13	-	-

Table 2.11-4: Summary of Samples Collected During the 2007 Lake Events

Station ID	Approximate Number of Sample Collected for Each Parameter Group at each Site					
	Chlorophyll *a*	Forms Of Phosphorus	Nitrogen Compounds	THM	Water Quality Parameters	Phytoplankton
Primary Lake Stations						
LK-01	3	8	4		4	3
LK-02	3	8	4		4	3
LK-03	3	8	4		4	3
LK-04	3	8	4		4	3
Raw Water Intakes						
RWI-CHRWD13	3			2		2
RWI-CHRWD2	3			3		2
RWI-GOREPWA	3			2		2

Figure 2.13-1: Total Phosphorus Concentration in Sediment and Poultry House Density Used for Reference Location Selection

Stream Name	Station ID	Total P in Sediment mg/Kg	Chicken Houses per Square Mile in watershed	Sampling Period
Spring Creek	BS-REF3	237	0.75	2005
Little Lee Creek	RS-10003/BS-REF1	117	0.14	2005-2007
Dry Creek	BS-REF2	91	<0.01	2005
Little Lee Creek	RS-10004	-	0.042	2006-2007

Table 2.13-2: Number of Sampling Events for Each Parameter Group at the Primary Reference Stream Locations

Parameter Group	Number of Sampling Events BS-REF1	BS-REF2	BS-REF3	RS-10004
Surface Water				
Bacteria	1	1	1	1
Chloride	2	1	1	3
Chlorophyll a	2	-	-	3
Dissolved Metals	1	1	1	1
Estrogens	1	1	1	1
Forms Of P	12	1	1	12
Nitrogen Compounds	3	1	1	3
Sulfate	1	1	1	1
Total Metals	1	1	1	1
Total/Dissolved Organic Carbon	1	-	-	-
Total/Dissolved Solids	1	1	1	1
Sediment				
Bacteria	2	1	2	-
Chloride	2	1	2	-
Estrogens	1	1	1	-
Forms Of P	2	1	2	-
Nitrogen Compounds	2	1	2	-
Sediment Toxicity	1	1	1	-
Soil/Sediment Classifications	2	1	2	-
Sulfate	2	1	2	-
Total Metals	2	1	2	-
Biota				
Benthic Macroinvertebrates	3	1	1	2
Periphyton	3	1	1	3
Fish	2	1	1	1

Table 2.13-3: Comparison of Reservoirs Selected as Potential Reference Locations to Lake Tenkiller

	Tenkiller	Broken Bow	Stockton Lake	Clearwater Lake	Table Rock
Reservoir	Yes	Yes	Yes	Yes	Yes
Year Constructed	1952	1970	1969 (impoundment began)	Begun 1940 Completed 1948-1951	Completed 1954-1958 (1959)
Major Tributary	Illinois River	Mountain Fork River	Little Sac River	Black River	White River
Existing WQ Data			Chlorophyll, Total-P, transparency data at a deep station that is oligotrophic; 21 years	Chlorophyll, Total-P, transparency data at a deep station that is oligotrophic; 20 years	Chlorophyll, Total-P, transparency data at a deep station that is oligotrophic; 20 years
EPA EcoRegion	39 (Ozark Highlands)	36 (Ouachita Mountains)	39 (Ozark Highlands)	39 (Ozark Highlands)	39 (Ozark Highlands)
Relevant State and Counties	Adair,OK Delaware, OK Benton, AR Washington, AR	OK	Cedar, MO Polk, MO	Reynolds, MO Iron, MO Wayne, MO Butler, MO	
Mean Depth	~ 16 m	19.7 m	12.3 m	11.7 m	19.2 m
Surface Area (flood control pool; acres)			38,300	10,250	52,300
Surface Area (multipurpose pool; acres)	12,906 (normal pool)	14,211 (normal pool)	24,300	1,650 (conservation pool)	43,100 (conservation pool)
Storage Flood Control Pool (acre-ft)	1,230,800	1,368,245	875,000	413,000	3,462,000
Storage Multipurpose Pool(acre-ft)	654,100	918,090	776,000	22,000 (conservation pool)	2,702,000
Drainage Area (mi^2)	1,610	754	1,150	898	4,020
Poultry Population (2002 Broiler Sales)	110,471,049	30,727,935	30,725	30,735	16,679,124
Poultry Population (2002 Turkey Sales)	3,208,345	0	79,061	0	861,588
Cattle Population	212,527	47,930	23,113	1,850	27,888
Swine Population (2002 Hog Sales)	146,856	81,981	1,041	27	8,000
Summer Average Chlorophyll-A (mg/L)			5.7	4.5	4.3
Total P (mg/L)			11	14	10

Figure 2.13-4 Summary of Samples Collected at Broken Bow Reservoir and Stockton Lake, 2007

Station ID	Approximate Number of Samples Collected for Each Parameter Group at each Site							
	Surface Water Samples						Sediment Samples	
	Chlorophyll *a*	Forms of Phosphorus	Nitrogen Compounds	THM	Water Quality Parameters	Phytoplankton	Sediment Chemistry	Benthic Macro-invertebrates
Broken Bow Reservoir								
BBL-03	2	6	2	-	2	2	1	1
BBL-06	2	6	2	2	2	2	1	1
BBL-07	2	6	2	-	2	2	1	1
BBL-08	2	6	2	2	2	2	1	1
Stockton Lake								
SLK-01	2	6	2	2	2	2	1	1
SLK-02	2	6	2	-	2	2	1	1
SLK-03	2	6	2	2	2	2	1	1
SLK-04	2	6	2	-	2	2	1	1
SLK-05	2	6	2	-	2	2	-	-

Table 2.14-1 Summary of Number and Type of Manure Samples Collected

Fecal Source	Number of Samples for DNA Analysis	Number of Samples for Full Suite Chemical Analyses
Beef Cattle	31	10
Dairy Cattle	6	-
Ducks	11	-
Geese	11	-
Humans	7	-
Swine	3	-

Table 2.15-1: Summary of the Poultry House Datasets Created and Used During the Course of the Investigation

	Preliminary Dataset	Interim Dataset	Final Dataset
Database issue date	2005	7/1/2006	4/22/2008
Aerial Imagery Source	2001 OSU data and 2003-2004 NAIP Aerials	2005 mosaic	2005 mosaic
Raw House Count	3629	3656	3656
Abandoned Houses	-	345	361
Active Houses	-	1967	1918
Inactive Houses	-	826	836
N/A	-	121	137
Removed Houses	-	106	110
Status Unknown	-	291	294
Source of Status Information	None	Aerial photographs, preliminary field investigation	Aerial photographs, 2007-2008 field investigations

Table 3.3-1: Primary Analysis Performed on Solid Samples

Parameter	Approx. # of Samples	Laboratory	Method No.	Method Title
Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods (SW-846), Third Edition, Final Update III				
Metals and P	264	A&L	6020/3050(prep)	Total and dissolved metals by Inductively Coupled Plasma-Mass Spectrometry
Metals and P	96	A&L, Aquatic	6010/3050(prep)	Total and dissolved metals by Inductively Coupled Plasma-Atomic Emission Spectrometry
Mercury	230	A&L	7471	Mercury in solid or semisolid waste (Manual Cold Vapor techniques) / in Liquid Waste
pH	47	A&L	9045D	Soil and Waste pH
Standard Methods for the Examination of Water and Wastewater, 20th Edition 1998				
Staphylococcus aureus	37	EML	9213B	Swimming Pools
Total Coliform	132	EML	9221B	Standard Total Coliform Fermentation Technique
Fecal Coliform	127	EML	9221E	Fecal Coliform Procedure
E. coli	52	A&L	9221F	*Escherichia coli* Procedure
Fecal Coliform	40	A&L	9222D	Fecal Coliform Membrane Filter Procedure
Enterococcus Group	132	EML	9230B	Fecal Streptococcus and Enterococcus Groups Multiple-Tube Technique
Enterococcus	64	A&L	9230C	Fecal Streptococcus and Enterococcus Groups Membrane Filter Technique
Salmonella species	36	EML	9260B	General Qualitative Isolation and Identification Procedure for *Salmonella*
Salmonella	40	A&L	9260D	Quantitative *Salmonella* Procedure
Bacteriological Analytical Manual, 8th Edition 1998, FDA				
Staphylococcus aureus	24	A&L	BAM-12	Staphylococcus aureus
Salmonella species	98	EML	BAM-5	Salmonella
Campylobacter species	55	EML	BAM-7	Campylobacter
Coliform Plate Count	24	A&L	BAM-4 (ECOLI PC)	Enumeration of *Escherichia coli* and the Coliform Bacteria
Methods of Phosphorus Analysis for Soils, Sediments, Residuals, and Waters				
Mehlich 3	347	A&L	Mehlich 3	Soil Test Phosphorus: Mehlich 3

Table 3.3-1: Primary Analysis Performed on Solid Samples

Parameter	Approx. # of Samples	Laboratory	Method No.	Method Title
Miscellaneous Methods				
Estrogens	96	GEL	GEL SOP	LCMS Analysis of Estrogen in Solids
Soil Texture	212	A&L	Soil Texture	Methods of Soil Analysis, Part 2 – Chemical and Microbiological Properties, 2nd Edition, 1982
SOIL PH 1:1	256	A&L	SOIL PH 1:1	Methods of Soil Analysis, Part 2 – Chemical and Microbiological Properties, 2nd Edition, 1982
SOLUBLE SALTS 1:2	231	A&L	Soluble Salts 1:2	Methods of Soil Analysis, Part 2 – Chemical and Microbiological Properties, 2nd Edition, 1982
Nitrate-N (Water Soluble) Phosphorus (Water Soluble) Sulfate Chloride Ammonium	202	A&L	SOLUBLE NUTRIENTS	Methods of Soil Analysis, Part 2 – Chemical and Microbiological Properties, 2nd Edition, 1982
WALKLEY-BLACK	69	A&L	WALKLEY-BLACK	Methods of Soil Analysis, Part 2 – Chemical and Microbiological Properties, 2nd Edition, 1982
OM-WB-COLOR	280	A&L	OM-WB-COLOR	Methods of Soil Analysis, Part 2 – Chemical and Microbiological Properties, 2nd Edition, 1982
SOIL TOTAL N	314	A&L	SOIL TOTAL N	Methods of Soil Analysis, Part 2 – Chemical and Microbiological Properties, 2nd Edition, 1982

Table 3.3-2: Primary Analysis Performed on Aqueous Samples

Parameter	Approx. # of Samples	Laboratory	Method No.	Method Title
Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods (SW-846), Third Edition, Final Update III				
Metals and P	1043	A&L	6020/3050(prep)	Total and dissolved metals by Inductively Coupled Plasma-Mass Spectrometry
Metals and P	316	A&L, Aquatic	6010/3050(prep)	Total and dissolved metals by Inductively Coupled Plasma-Atomic Emission Spectrometry
Methods for Chemical Analysis of Water and Wastes, 3rd Edition, March 1983				
Mercury	1030	A&L	245.1	Manual Cold Vapor technique
Conductivity	194	A&L	120.1	Conductance, Specific Conductance
pH	407	A&L	150.1	pH, Electrometric Measurement
Total Dissolved Solids	856	A&L	160.1	Residue, Filterable, Gravimetric, Dried at 180°C (TDS)
Total Suspended Solids	861	A&L	160.2	Residue, Non-Filterable, Gravimetric, Dried at 103-105°C (TSS)
Turbidity	283	A&L	180.1	Turbidity, Nephelometric
Chloride, Nitrate + Nitrite (as N) and Sulfate	1232	A&L	300.0	Anions by Ion Chromatography
Alkalinity	512	A&L	310.1	Alkalinity (Titrimetric pH 4.5)
Ammonia Nitrogen	82	A&L	350.2	Nitrogen (Ammonia, Colorimetric, Titrimetric, Potentiometric Distillation Procedure)
Ammonia Nitrogen	393	A&L	350.3	Nitrogen (Ammonia, Potentiometric Ion Selective Electrode)
Total Kjeldahl Nitrogen (TKN)	1097	A&L	351.3	Nitrogen (Kjeldahl, Total, Colorimetric, Titrimetric, Potentiometric)
Total Phosphorus Total Dissolved Phosphorous Total Ortho Phosphorus	354	A&L	365.2	Phosphorus (All Forms, Colorimetric, Ascorbic Acid, Single Reagent)
Chemical Oxygen Demand	124	A&L	410.4	Chemical Oxygen Demand (Colorimetric, Automated; Manual)
Total Organic Carbon	1396	A&L	415.1	Organic Carbon (Total, Combustion or Oxidation)
Standard Methods for the Examination of Water and Wastewater, 20th Edition 1998				
Nitrogen (Nitrate)	53	A&L	4500NO3-E	Cadmium Reduction Method
Alkalinity	79	A&L	2320B	Titration Method
Total Dissolved Solids	63	A&L, Aquatic	2540C	Total Dissolved Solids Dried at 180°C
Total Suspended Solids	61	A&L	2540D	Total Suspended Solids Dried at 103-105°C
pH	61	A&L	4500H^+ B.	Electrometric Method
Ammonia Nitrogen	63	A&L	4500-NH3D	Ammonia-Selective Electrode Method
Total Kjeldahl nitrogen (TKN)	168	A&L	4500-N_{org}-TKN	Macro Kjeldahl Method
Nitrate + Nitrite (as N)	63	A&L	4500-NO3E	Cadmium Reduction Method

Table 3.3-2: Primary Analysis Performed on Aqueous Samples

Parameter	Approx. # of Samples	Laboratory	Method No.	Method Title
Soluble Reactive P Total Phosphorus Total Dissolved Phosphorous	1950	Aquatic	4500PF	Automated Ascorbic Acid Reduction Method
Disinfection By-Products (Haloacetic acids and Trichlorophenol)	45	Alpha	6251	Disinfection By-Products
Total Organic Carbon	20	A&L	5310B	High Temperature Combustion Method
THMFP as CHCl3	76	A&L	5710B	Trihalomethane Formation Potential (THMFP)
Staphylococcus aureus	112	EML	9213B	Swimming Pools
Total Coliform	645	EML	9221B	Standard Total Coliform Fermentation Technique
Fecal Coliform	643	EML	9221E	Fecal Coliform Procedure
E. coli	642	A&L	9221F	*Escherichia coli* Procedure
Enterococcus Group	639	EML	9230B	Fecal Streptococcus and Enterococcus Groups Multiple-Tube Technique
Salmonella species	97	EML	9260B	General Qualitative Isolation and Identification Procedure for *Salmonella*
Chlorophyll a, corrected	631	Aquatec	10200H3-C	Chlorophyll – Fluorometric Determination of Chlorophyll *a*
Chlorophyll a, uncorrected	631	Aquatec	10200H3-U	Chlorophyll – Fluorometric Determination of Chlorophyll *a*
Bacteriological Analytical Manual, 8th Edition 1998, FDA				
Staphylococcus aureus	527	EML, A&L	BAM-12	Staphylococcus aureus
Salmonella species	541	EML	BAM-5	Salmonella
Campylobacter spp	108	Food Protech	Food Protech SOP	Not Provided
Campylobacter species	276	EML	BAM-7	Campylobacter
Estrogens	539	GEL	GEL SOP	LCMS Analysis of Estrogens in Water
Microcystin / *GWL*	18	GWL	(ELISA) from Abraxis	Not Provided

Table 3.3-3: Miscellaneous, Infrequently Used Methods

Parameter	Laboratory	Method No.	Method Title
Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods (SW-846), Third Edition, Final Update III			
Semivolatile Organic Compounds	A&L	8270C	Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)
Mercury	A&L	7470A	Mercury in solid or semisolid waste (Manual Cold Vapor techniques) / in Liquid Waste
pH	A&L	9045D	Soil and Waste pH
Volatile Organic Compounds	Alpha	524.2	Drinking Water method - Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)
Methods for Chemical Analysis of Water and Wastes, 3rd Edition, March 1983			
Metals	A&L, Aquatic	200.7	Inductively Coupled Plasma-Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes
Chloride	A&L, Aquatic	325.3	Chloride (Titrimetric, Mercuric Nitrate)
Solids Total	Aquatic	160.3	Residue, Total Gravimetric, Dried at 103-105° C(TS)
Total antimony	A&L, Aquatic	200.9	Total antimony (Graphite Furnace Atomic Absorption)
Total Arsenic	A&L, Aquatic	206.2	Total Arsenic (Graphite Furnace Atomic Absorption)
Total Lead	A&L, Aquatic	239.2	Total Lead (Graphite Furnace Atomic Absorption)
Total Organic Carbon	Aquatic	415.2	Organic Carbon (Total, UV Promoted, Persulfate Oxidation)
Standard Methods for the Examination of Water and Wastewater, 20th Edition 1998			
Sulfate	Aquatic	4500SO4-E	Turbidimetric Method
Nitrogen (Nitrate)	Aquatic	4500NO3-F	Automated Cadmium Reduction Method
Alkalinity	A&L	2320B	Titration Method
Total Solids	Aquatic	2540B	Total Solids Dried at 103-105°C
Total Dissolved Solids	A&L, Aquatic	2540C	Total Dissolved Solids Dried at 180°C
Total Suspended Solids	A&L	2540D	Total Suspended Solids Dried at 103-105°C
pH		$4500H^{+}$ B.	Electrometric Method
Nitrate + Nitrite (as N)	Aquatic	4500N03F	Automated Cadmium Reduction Method
Ammonia Nitrogen		4500-NH3D	Ammonia-Selective Electrode Method
Total Kjeldahl nitrogen (TKN)		4500-N_{org}-TKN	Macro Kjeldahl Method
Nitrate + Nitrite (as N)	A&L	4500-NO3E	Cadmium Reduction Method
Soluble Reactive P		4500PF	Automated Ascorbic Acid Reduction Method
Disinfection By-Products (Haloacetic acids and Trichlorophenol)	Alpha	6251B	Disinfection By-Products
Total Organic Carbon	A&L	5310B	High Temperature Combustion Method
THMFP as CHCl3	A&L	5710B	Trihalomethane Formation Potential (THMFP)

Table 3.3-3: Miscellaneous, Infrequently Used Methods

Parameter	Laboratory	Method No.	Method Title
Staphylococcus aureus	EML	9213B	Swimming Pools
Total Coliform	EML	9221B	Standard Total Coliform Fermentation Technique
Fecal Coliform	EML	9221E	Fecal Coliform Procedure
E_ coli	A&L	9221F	*Escherichia coli* Procedure R
Fecal Coliform	A&L	9222D	Fecal Coliform Membrane Filter Procedure
Enterococcus Group	EML	9230B	Fecal Streptococcus and Enterococcus Groups Multiple-Tube Technique
Enterococcus	A&L	9230C	Fecal Streptococcus and Enterococcus Groups Membrane Filter Technique
Salmonella species	EML	9260B	General Qualitative Isolation and Identification Procedure for *Salmonella*
Salmonella	A&L	9260D	Quantitative *Salmonella* Procedure
Campylobacter	A&L	9260G	*Campylobacter jejuni* R
Chlorophyll a, corrected	Aquatec	10200H3-C	Chlorophyll – Fluorometric Determination of Chlorophyll *a*
Chlorophyll a, uncorrected	Aquatec	10200H3-U	Chlorophyll – Fluorometric Determination of Chlorophyll *a*
Bacteriological Analytical Manual, 8th Edition 1998, FDA			
Campylobacter species	Food Protech - Solids	BAM-7	Campylobacter
Coliform Plate Count	Food Protech - Solids	BAM-4 (ECOLI PC)	Enumeration of *Escherichia coli* and the Coliform Bacteria
Coliform Plate Count	A&L	BAM-4 (ECOLI PC)	Enumeration of *Escherichia coli* and the Coliform Bacteria
Salmonella species	Food Protech	BAM-5	Salmonella
Staphylococcus aureus	Food Protech	BAM-12	Staphylococcus aureus
Miscellaneous Methods			
Campylobacter spp, Coliforms, Enterococci	Food Protech	Food Protech	Method Title Not Provided
Campylobacter spp, Generic E_coli, Salmonella	Food Protech - Solids	Food Protech	Method Title Not Provided

Table 3.4-1: Laboratories

Laboratory	Type of Data
A&L Laboratories Inc., Memphis, Tennessee	Metals, Nutrients, water quality
Alpha Analytical Laboratories, Westborough, Massachusetts	Total Trihalomethane formation potential (TTHM) and halo acetic acids (HAA)
Aquatec Biological Sciences (Aquatec)	Chlorophyll a and plankton
Aquatic Research, Seattle, Washington (Aquatic Research)	Total P, total dissolved P, soluble reactive P
Environmental Microbiological Laboratory, San Bruno CA, (EML)	Bacteria
Environmental Testing and Consulting, Inc. (ETC)	Chlorophyll a and plankton
Food Protech	Bacteria
Great Lakes Environmental Center Travers City, MI (GLEC)	Chlorophyll a and plankton
GEL Analytics, LLC Golden, CO (GEL)	Estrogens
Waters Edge Scientific, Baraboo WI, (WES	Benthic analysis (Algae, diatoms)
Reservoirs Environmental, Denver, CO	Dust and Metals in Air
Northwind Inc, Idaho Falls, ID	PCR
Green Water Labs (GWL) Palatka, FL	Microcystin
Michigan State University (MSU), East Lansing, MI	Benthic macroinvertebrate identification
Chadwick/GEI, Littleton, CO	Benthic macroinvertebrate identification
Jeff Janik, PhD, Davis, CA	Phytoplankton/zooplankton identification

Table 3.7.4-1: Completeness - Aqueous

Parameter	Laboratory	Number Qualified	Number Rejected	% qualified	% rejected	Total Analyzed	% Completeness
Semi-Volatile Organic Compounds	A&L	0	0	0.00%	0.00%	1	100.00%
Volatile Organic Compounds	A&L	0	0	0.00%	0.00%	1	100.00%
1,2-Dichlorobenzene-d4	AAL	0	0	0.00%	0.00%	64	100.00%
17a-estradiol	GEL	131	86	19.85%	13.03%	660	86.97%
17b-estradiol	GEL	192	86	29.09%	13.03%	660	86.97%
2,3-Dibromopropionic Acid	AAL	0	0	0.00%	0.00%	55	100.00%
4-Bromofluorobenzene	AAL	0	0	0.00%	0.00%	64	100.00%
Alkalinity (as CaCO3)	A&L	106	0	15.38%	0.00%	689	100.00%
Alkalinity (as CaCO3)	Aquatic	0	0	0.00%	0.00%	2	100.00%
Ammonia Nitrogen	A&L	2	0	0.33%	0.00%	612	100.00%
Brevibacteria 16S rRNA	Northwind/ISU	0	0	0.00%	0.00%	32	100.00%
Bromochloroacetic Acid	AAL	0	0	0.00%	0.00%	55	100.00%
Bromodichloromethane	AAL	0	0	0.00%	0.00%	69	100.00%
Bromoform	AAL	0	0	0.00%	0.00%	69	100.00%
Campylobacter	A&L	2	2	100.00%	100.00%	2	0.00%
Campylobacter species	EML	0	0	0.00%	0.00%	292	100.00%
Campylobacter spp.	FoodProtech	116	116	100.00%	100.00%	116	0.00%
Chloride	A&L	83	0	11.89%	0.00%	698	100.00%
Chloride	Aquatic	0	0	0.00%	0.00%	2	100.00%
Chloroform	AAL	0	0	0.00%	0.00%	69	100.00%
Chlorophyll a	GLEC	0	0	0.00%	0.00%	12	100.00%
Chlorophyll a, corrected	Aquatec	0	0	0.00%	0.00%	700	100.00%
Chlorophyll a, uncorrected	Aquatec	0	0	0.00%	0.00%	700	100.00%
COD (Chemical Oxygen Demand)	A&L	42	0	30.88%	0.00%	136	100.00%
COD (Chemical Oxygen Demand)	Aquatic	0	0	0.00%	0.00%	2	100.00%
Coliforms	FoodProtech	0	0	0.00%	0.00%	116	100.00%
Conductivity	A&L	0	0	0.00%	0.00%	247	100.00%
Dibromoacetic Acid	AAL	0	0	0.00%	0.00%	55	100.00%
Dibromochloromethane	AAL	0	0	0.00%	0.00%	69	100.00%
Dichloroacetic Acid	AAL	0	0	0.00%	0.00%	55	100.00%
Dissolved Aluminum	A&L	0	0	0.00%	0.00%	705	100.00%
Dissolved Antimony	A&L	0	0	0.00%	0.00%	705	100.00%
Dissolved Arsenic	A&L	0	0	0.00%	0.00%	805	100.00%
Dissolved Barium	A&L	4	0	0.57%	0.00%	705	100.00%
Dissolved Beryllium	A&L	0	0	0.00%	0.00%	705	100.00%
Dissolved Boron	A&L	0	0	0.00%	0.00%	9	100.00%
Dissolved Cadmium	A&L	0	0	0.00%	0.00%	705	100.00%
Dissolved Calcium	A&L	3	0	0.43%	0.00%	705	100.00%
Dissolved Chromium	A&L	0	0	0.00%	0.00%	705	100.00%
Dissolved Cobalt	A&L	0	0	0.00%	0.00%	705	100.00%
Dissolved Copper	A&L	0	0	0.00%	0.00%	805	100.00%
Dissolved Iron	A&L	0	0	0.00%	0.00%	705	100.00%
Dissolved Lead	A&L	0	0	0.00%	0.00%	705	100.00%

Table 3.7.4-1: Completeness - Aqueous

Parameter	Laboratory	Number Qualified	Number Rejected	% qualified	% rejected	Total Analyzed	% Completeness
Dissolved Magnesium	A&L	0	0	0.00%	0.00%	705	100.00%
Dissolved Manganese	A&L	0	0	0.00%	0.00%	705	100.00%
Dissolved Mercury	A&L	0	0	0.00%	0.00%	686	100.00%
Dissolved Molybdenum	A&L	0	0	0.00%	0.00%	640	100.00%
Dissolved Nickel	A&L	0	0	0.00%	0.00%	705	100.00%
Dissolved Ortho P (365.2)	A&L	0	0	0.00%	0.00%	403	100.00%
Dissolved Potassium	A&L	7	0	0.99%	0.00%	705	100.00%
Dissolved Selenium	A&L	0	0	0.00%	0.00%	705	100.00%
Dissolved Silver	A&L	0	0	0.00%	0.00%	705	100.00%
Dissolved Sodium	A&L	0	0	0.00%	0.00%	705	100.00%
Dissolved Strontium	A&L	0	0	0.00%	0.00%	9	100.00%
Dissolved Thallium	A&L	0	0	0.00%	0.00%	705	100.00%
Dissolved Titanium	A&L	0	0	0.00%	0.00%	9	100.00%
Dissolved Vanadium	A&L	0	0	0.00%	0.00%	705	100.00%
Dissolved Zinc	A&L	21	0	2.61%	0.00%	805	100.00%
DOC	A&L	0	0	0.00%	0.00%	211	100.00%
E. coli	EML	0	0	0.00%	0.00%	729	100.00%
E-coli Plate Count	A&L	2	2	100.00%	100.00%	2	0.00%
Enterococci	FoodProtech	0	0	0.00%	0.00%	106	100.00%
Enterococcus	A&L	2	2	100.00%	100.00%	2	0.00%
Enterococcus Group	EML	0	0	0.00%	0.00%	729	100.00%
Estriol	GEL	131	86	19.85%	13.03%	660	86.97%
Estrone	GEL	131	86	19.85%	13.03%	660	86.97%
Fecal Coliform	A&L	0	0	0.00%	0.00%	2	100.00%
Fecal Coliform	EML	0	0	0.00%	0.00%	729	100.00%
Fecal Coliform	FoodProtech	17	17	14.66%	14.66%	116	85.34%
Generic E. coli	FoodProtech	116	116	100.00%	100.00%	116	0.00%
Microcystin	GWL	0	0	0.00%	0.00%	19	100.00%
Monobromoacetic Acid	AAL	0	0	0.00%	0.00%	55	100.00%
Monochloroacetic Acid	AAL	0	0	0.00%	0.00%	55	100.00%
Nitrite + Nitrate (as N)	A&L	19	0	1.36%	0.00%	1402	100.00%
Nitrite + Nitrate (as N)	Aquatic	0	0	0.00%	0.00%	14	100.00%
pH	A&L	0	0	0.00%	0.00%	549	100.00%
Salmonella (MPN)	A&L	0	0	0.00%	0.00%	3	100.00%
Salmonella species	EML	0	0	0.00%	0.00%	728	100.00%
Salmonella spp.	FoodProtech	116	116	100.00%	100.00%	116	0.00%
Soluble Reactive P (4500PF)	Aquatic	0	0	0.00%	0.00%	2123	100.00%
Staphylococcus	A&L	0	0	0.00%	0.00%	2	100.00%
Staphylococcus aureus	EML	0	0	0.00%	0.00%	726	100.00%
Staphylococcus aureus	FoodProtech	0	0	0.00%	0.00%	85	100.00%
Staphylococcus spp.	FoodProtech	0	0	0.00%	0.00%	31	100.00%
Sulfate	Aquatic	0	0	0.00%	0.00%	14	100.00%
TOC	A&L	0	0	0.00%	0.00%	1394	100.00%
TOC	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Aluminum	A&L	9	0	1.37%	0.00%	658	100.00%
Total Aluminum	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Antimony	A&L	19	0	2.89%	0.00%	658	100.00%

Table 3.7.4-1: Completeness - Aqueous

Parameter	Laboratory	Number Qualified	Number Rejected	% qualified	% rejected	Total Analyzed	% Completeness
Total Antimony	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Arsenic	A&L	3	0	0.40%	0.00%	758	100.00%
Total Arsenic	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Barium	A&L	0	0	0.00%	0.00%	658	100.00%
Total Barium	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Beryllium	A&L	0	0	0.00%	0.00%	658	100.00%
Total Beryllium	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Cadmium	A&L	0	0	0.00%	0.00%	658	100.00%
Total Cadmium	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Calcium	A&L	0	0	0.00%	0.00%	658	100.00%
Total Calcium	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Chromium	A&L	0	0	0.00%	0.00%	658	100.00%
Total Chromium	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Cobalt	A&L	0	0	0.00%	0.00%	658	100.00%
Total Cobalt	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Coliform	A&L	0	0	0.00%	0.00%	2	100.00%
Total Coliform	EML	0	0	0.00%	0.00%	729	100.00%
Total Copper	A&L	9	0	1.19%	0.00%	758	100.00%
Total Copper	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Dissolved P (365.2)	A&L	0	0	0.00%	0.00%	400	100.00%
Total Dissolved P (4500PF)	Aquatic	0	0	0.00%	0.00%	2123	100.00%
Total Dissolved P (6010)	A&L	176	0	98.88%	0.00%	178	100.00%
Total Dissolved P (6020)	A&L	3	0	0.48%	0.00%	623	100.00%
Total Dissolved Solids	A&L	368	0	35.38%	0.00%	1040	90.77%
Total Dissolved Solids	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Iron	A&L	0	0	0.00%	0.00%	658	100.00%
Total Iron	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Kjeldahl Nitrogen	A&L	36	0	2.55%	0.00%	1413	100.00%
Total Kjeldahl Nitrogen	Aquatic	0	0	0.00%	0.00%	14	100.00%
Total Lead	A&L	0	0	0.00%	0.00%	658	100.00%
Total Lead	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Magnesium	A&L	0	0	0.00%	0.00%	658	100.00%
Total Magnesium	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Manganese	A&L	0	0	0.00%	0.00%	658	100.00%
Total Manganese	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Mercury	A&L	1	1	0.15%	0.15%	658	99.85%
Total Mercury	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Molybdenum	A&L	12	0	2.15%	0.00%	558	100.00%
Total Molybdenum	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Nickel	A&L	0	0	0.00%	0.00%	658	100.00%
Total Nickel	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total ortho P (365.2)	A&L	0	0	0.00%	0.00%	402	100.00%
Total P (365.2)	A&L	0	0	0.00%	0.00%	387	100.00%
Total P (4500PF)	Aquatic	0	0	0.00%	0.00%	2102	100.00%
Total P (6010)	A&L	178	0	98.89%	0.00%	180	100.00%
Total P (6020)	A&L	17	0	2.97%	0.00%	572	100.00%
Total Potassium	A&L	8	0	1.22%	0.00%	658	100.00%

Table 3.7.4-1: Completeness - Aqueous

Parameter	Laboratory	Number Qualified	Number Rejected	% qualified	% rejected	Total Analyzed	% Completeness
Total Potassium	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Selenium	A&L	9	0	1.37%	0.00%	658	100.00%
Total Selenium	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Silver	A&L	3	0	0.46%	0.00%	658	100.00%
Total Silver	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Sodium	A&L	0	0	0.00%	0.00%	658	100.00%
Total Sodium	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Sulfate (SO4)	A&L	19	0	2.95%	0.00%	644	100.00%
Total Suspended Solids	A&L	300	0	29.10%	0.00%	1031	95.83%
Total Suspended Solids	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Thallium	A&L	0	0	0.00%	0.00%	658	100.00%
Total Thallium	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Vanadium	A&L	0	0	0.00%	0.00%	658	100.00%
Total Vanadium	Aquatic	0	0	0.00%	0.00%	2	100.00%
Total Zinc	A&L	9	0	1.19%	0.00%	758	100.00%
Total Zinc	Aquatic	0	0	0.00%	0.00%	2	100.00%
Trichloroacetic Acid	AAL	0	0	0.00%	0.00%	55	100.00%
TTHM as CHCl3	AAL	0	0	0.00%	0.00%	54	100.00%
TTHMFP as CHCl3	A&L	0	0	0.00%	0.00%	91	100.00%
TTHMFP as CHCl3	AAL	0	0	0.00%	0.00%	11	100.00%
Turbidity	A&L	94	68	30.42%	22.01%	309	77.99%
Total		**2516**	**784**	**3.95%**	**1.23%**	**63654**	**98.7%**

Table 3.7.4-2: Completeness - Solids

Parameter	Laboratory	Number Qualified	Number Rejected	% qualified	% rejected	Total Analyzed	% Completeness
%Clay	A&L	0	0	0.00%	0.00%	242	100.00%
%Sand	A&L	0	0	0.00%	0.00%	242	100.00%
%Silt	A&L	30	0	12.40%	0.00%	242	100.00%
10-Day % Survival	GLEC	0	0	0.00%	0.00%	40	100.00%
17a-estradiol	GEL	11	0	9.40%	0.00%	117	100.00%
17b-estradiol	GEL	45	21	32.61%	15.22%	138	84.78%
17b-estradiol-d3	GEL	21	21	15.22%	15.22%	138	84.78%
28-Day % Survival	GLEC	0	0	0.00%	0.00%	20	100.00%
AL BOUND P	Aquatic	0	0	0.00%	0.00%	15	100.00%
Ammonium (Water Soluble)	A&L	7	0	3.30%	0.00%	212	100.00%
Average Dry Weight	GLEC	0	0	0.00%	0.00%	40	100.00%
Brevibacteria 16S rRNA	Northwind/ISU	0	0	0.00%	0.00%	16	100.00%
CA BOUND P	Aquatic	0	0	0.00%	0.00%	15	100.00%
Campylobacter	A&L	41	41	100.00%	100.00%	41	0.00%
Campylobacter species	EML	0	0	0.00%	0.00%	58	100.00%
Campylobacter spp.	FoodProtech	12	12	100.00%	100.00%	12	0.00%
Chloride (Water Soluble)	A&L	2	0	0.94%	0.00%	212	100.00%
Coliform Plate Count	A&L	0	0	0.00%	0.00%	25	100.00%
Coliforms	FoodProtech	0	0	0.00%	0.00%	12	100.00%
E. coli	EML	0	0	0.00%	0.00%	156	100.00%
E-coli Plate Count	A&L	66	66	100.00%	100.00%	66	0.00%
Enterococci	FoodProtech	0	0	0.00%	0.00%	12	100.00%
Enterococcus	A&L	66	66	100.00%	100.00%	66	0.00%
Enterococcus Group	EML	0	0	0.00%	0.00%	156	100.00%
Estriol	GEL	32	21	23.19%	15.22%	138	84.78%
Estrone	GEL	32	21	23.19%	15.22%	138	84.78%
FE BOUND P	Aquatic	0	0	0.00%	0.00%	15	100.00%
Fecal Coliform	A&L	0	0	0.00%	0.00%	41	100.00%
Fecal Coliform	EML	0	0	0.00%	0.00%	156	100.00%
Fecal Coliform	FoodProtech	0	0	0.00%	0.00%	12	100.00%
Generic E. coli	FoodProtech	12	12	100.00%	100.00%	12	0.00%
LOOSLY BOUND P	Aquatic	0	0	0.00%	0.00%	15	100.00%
Moisture	A&L	0	0	0.00%	0.00%	476	100.00%
Moisture	Aquatic	0	0	0.00%	0.00%	15	100.00%
Nitrate-N (Water Soluble)	A&L	2	0	0.84%	0.00%	237	100.00%
Nitrogen Ammoniacal	A&L	0	0	0.00%	0.00%	4	100.00%
Nitrogen Total (Inorganic + Organic)	A&L	16	0	3.60%	0.00%	445	100.00%
Organic Matter	A&L	0	0	0.00%	0.00%	472	100.00%
Organic Matter (Combustion)	A&L	0	0	0.00%	0.00%	6	100.00%
pH	A&L	0	0	0.00%	0.00%	429	100.00%
Phosphorus (Mehlich 3)	A&L	26	0	6.75%	0.00%	385	100.00%
Phosphorus (Water Soluble)	A&L	4	0	1.69%	0.00%	237	100.00%
Salmonella (MPN)	A&L	0	0	0.00%	0.00%	41	100.00%
Salmonella species	EML	0	0	0.00%	0.00%	156	100.00%
Salmonella spp.	FoodProtech	12	12	100.00%	100.00%	12	0.00%
Solids Total	A&L	0	0	0.00%	0.00%	476	100.00%